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New Data on Austroalpine Liassic Ammonites from the Adnet Quarries and Adjacent Areas (Oberösterreich, Northern Calcareous Alps)

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17 Text-Figures and 10 Plates

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Neue Daten zu ostalpinen Lias-Ammoniten aus Adnet und Umgebung (Oberösterreich, Nördliche Kalkalpen)

Zusammenfassung

Biostratigraphische Untersuchungen in den Steinbrüchen von Adnet (Salzburg) ermöglichen uns die Unterscheidung von 11 Faunenhorizonten im Ober-Hettang/Sinemur des Oberostalpins. Die regional sehr begrenzte Verbreitung von vielen der gefundenen Unterlias-Ammoniten [z.B. *Adnethiceras adnethicus* (HAUER), *Gleviceras doris* sensu PIA] und die noch sehr lückenhafte biostratigraphische Abfolge erschweren sowohl lokale Korrelationen als auch Vergleiche mit NW-Europa, dem Mittelostalpin und den Apenninen. Die Pliensbach-Fauna des Wetzsteingrabens zeigt dagegen sehr große Ähnlichkeiten zu anderen, zeitgleichen Ammoniten-Vorkommen des Oberostalpins und fügt sich zudem sehr gut in die biostratigraphischen Standardgliederungen für den euroborealen und tethyalen Raum ein.

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Abstract

The biostratigraphic studies of ammonites from the Adnet quarries allow to propose a set of 11 horizons or levels for the Upper Austroalpine Late Hettangian–Sinemurian. The originality of the faunal assemblages [e.g. *Adnethiceras adnethicus* (HAUER), *Gleviceras doris* sensu PIA] and the discontinuity of the biostratigraphical sequence make local comparisons and correlations with NW Europe, the Middle Austroalpine and the Apennines rather difficult. By contrast, the Pliensbachian fauna from Wetzsteingraben presents a clear faunal homogeneity with the other studied regions of the Upper Austroalpine. Moreover, they well integrate with the Euroboreal and Tethyan standard biostratigraphical framework.

Nouvelles données sur les ammonites liasiques de l'Austroalpin pour les carrières d'Adnet et les régions adjacentes (Autriche, Alpes Calcaires septentrionales)

Résumé

L'étude des ammonites dans les carrières d'Adnet permet de proposer une série de 11 horizons ou niveaux pour l'Hettangien supérieur et le Sinémurien de l'Austroalpin supérieur. L'originalité des assemblages fauniques [e.g. *Adnethiceras adnethicus* (HAUER), *Gleviceras doris* sensu PIA] et la discontinuité de la séquence biostratigraphique rendent parfois difficiles les comparaisons locales et les corrélations avec l'Europe du nord-ouest, le domaine de l'Austroalpin moyen et les Apennins. Les faunes pliensbachiennes du Wetzsteingraben présentent par contre une nette homogénéité pour les associations fauniques avec les autres régions de l'Austroalpin supérieur et elles s'intègrent aisément dans les cadres biostratigraphiques proposés pour le domaine euroboréal et le domaine téthysien.

1. Introduction

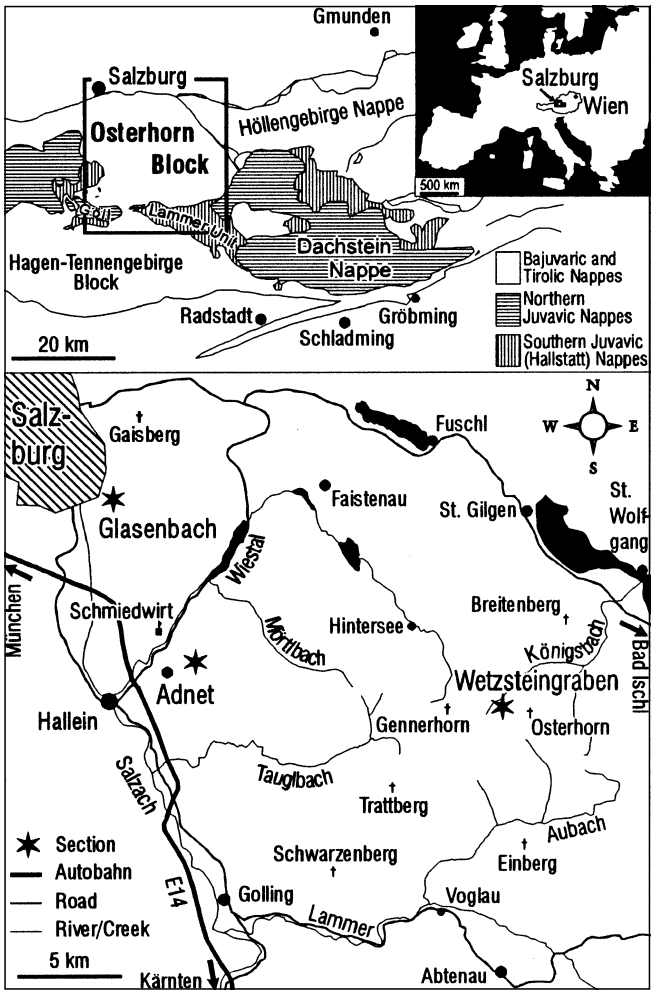
This paper is a complement to the recent study of MEISTER & BÖHM (1993). It's intention is to improve the Sinemurian and Pliensbachian stratigraphy of the Northern Calcareous Alps. We present results from modern taxonomic and biostratigraphic investigations of a famous classical site of stratigraphic research: the quarries of Adnet, and of two other localities of the Osterhorn block: the Glasenbach Gorge and the Wetzsteingraben.

2. Regional Setting

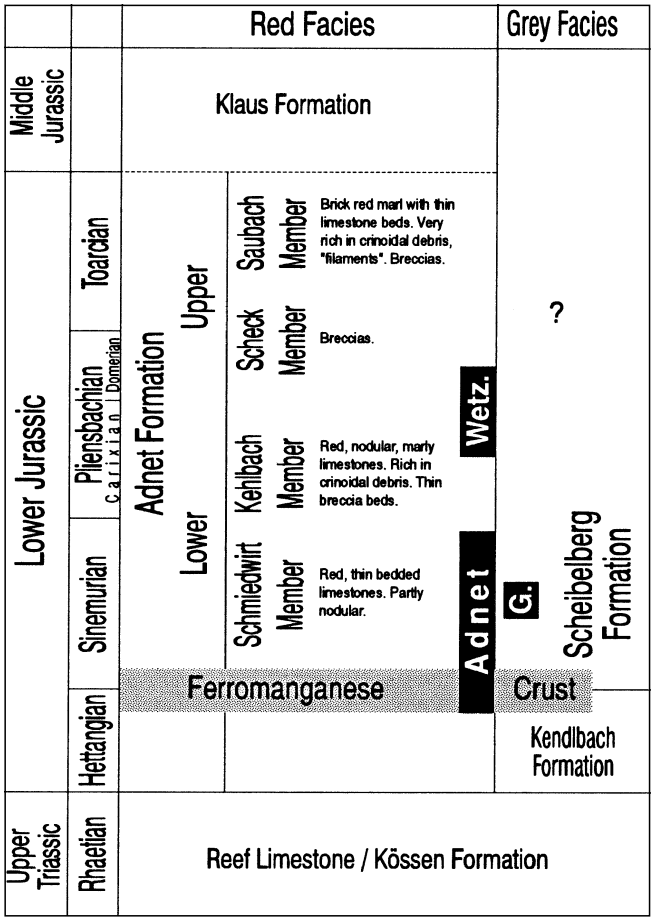
The quarries of the little village of Adnet, situated approximately 10 km southeast of the city of Salzburg (Austria), are the type locality of the Liassic Adnet Formation (Text-Fig. 1). This is a sequence of red limestones and marls, up to some 30 m thick, starting in the upper Hettangian and per definitionem passing over into the Middle Jurassic Klaus Formation at the end of the Liassic (KRYSTYN, 1971).

Rich ammonite faunas provided by the Adnet Limestones and excellent exposures available from the century old quarrying made Adnet a famous site of the stratigraphic pioneers during the second half of the 19th century (LIPOLD, 1851; HAUER, 1853, 1854, 1856; WÄHNER, 1882–98, 1886, 1903; AMMON, 1893; PIA, 1914). Surprisingly, in the 20th century very few papers about facies, stratigraphy or ammonite faunas of the Liassic of Adnet were published (WIEDMANN, 1970; KRYSTYN, 1971; WENDT, 1971). Some short reports and a geological map of the area were presented by SCHLAGER (1957, 1967, 1968, 1969, 1970) and SCHLAGER & SCHLAGER (1960). TOLLMANN (1976a) shortly discusses stratigraphy and facies of the Adnet Formation. KIESLINGER (1964) presents a complete list of the Adnet quarries with short lithological descriptions. Some papers dealing with special sedimentological aspects of the Adnet Formation were presented by HALLAM (1967), JURGAN (1969), HUDSON & JENKYNS (1969), HUDSON & COLEMAN (1978), BÖHM (1992b) and BÖHM & BRACHERT (1993). But they discuss stratigraphic aspects at most very briefly. Some new attempts to decipher the litho- and biostratigraphy of the Adnet Formation at its type locality can be found in BÖHM (1992a), MEISTER & BÖHM (1993) and BÖHM et al. (in press).

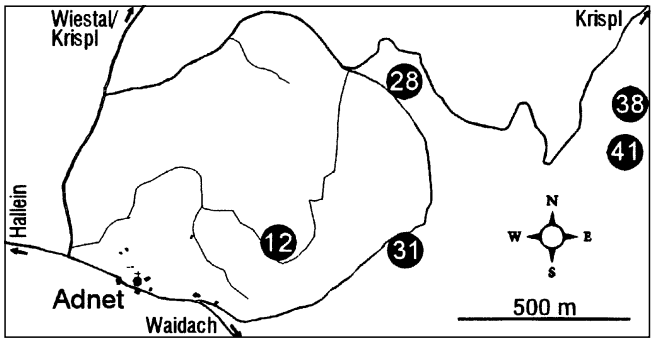
The Adnet area is part of the Osterhorn block, displaying unusually mild tectonic disturbance compared with other parts of the Northern Calcareous Alps. The Osterhorn Block is a part of the Tyrolic nappe system (Text-Fig. 1). Detailed desriptions of the settings of the Osterhorn Mountains are provided by TOLLMANN (1976b), PLÖCHINGER (1990) and BÖHM (1992a).



Text-Fig. 1.
Regional overview of the study area in the Osterhorn Mountains.
Studied outcrops indicated by stars.
Tectonic map after TOLLMANN (1976b).



Text-Fig. 2.
Stratigraphic setting of the study area in the Osterhorn Mountains.
The stratigraphic range of the studied sections is marked by black bars.
Wetz. = Wetzsteingraben; G. = Glasenbach Gorge.
Lithostratigraphic framework after BÖHM et al. (in press).



Text-Fig. 3.
Road map of the Adnet area showing the locations of the investigated quarries.
Quarry numbers refer to KIESLINGER (1964).

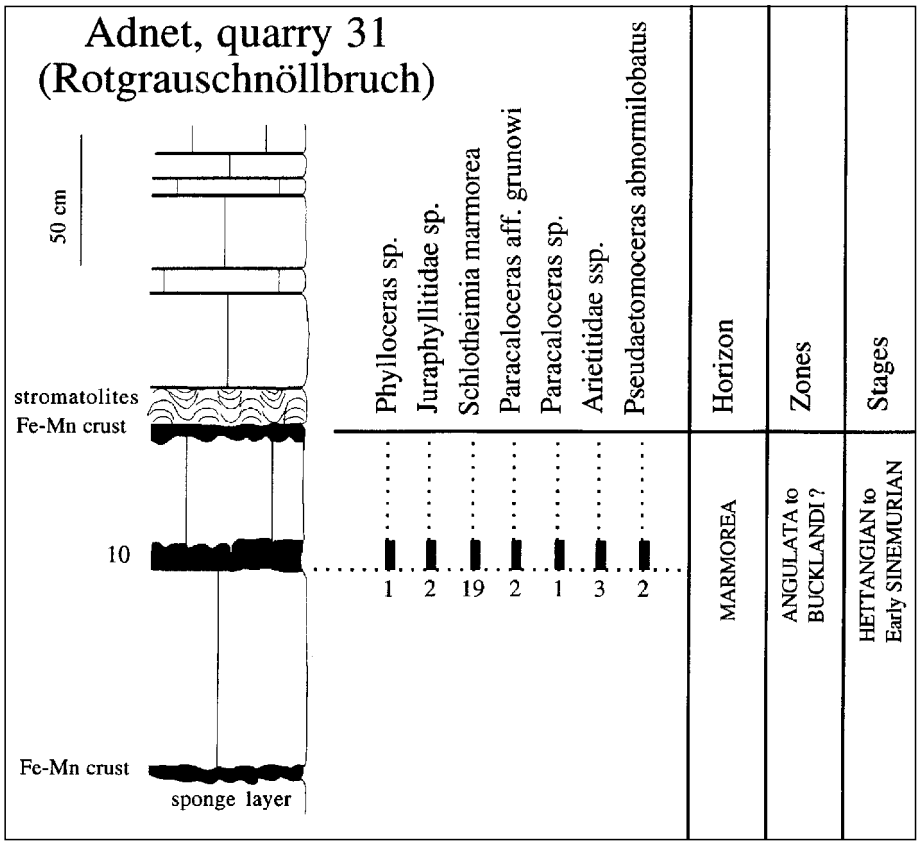
3. Lithological Description and Qualitative/Quantitative Ammonite Distribution

3.1. Adnet Quarries

The quarries of Adnet expose Late Triassic to late Liassic limestones. The Late Triassic (Rhaetian) reefs of Adnet are very famous for their coral thickets partly preserved in growth position. These reef limestones are overlain by Liassic hemipelagic deep-water limestones (BÖHM, 1992a,b; BÖHM & BRACHERT, 1993), which are partly rich in ammonites.

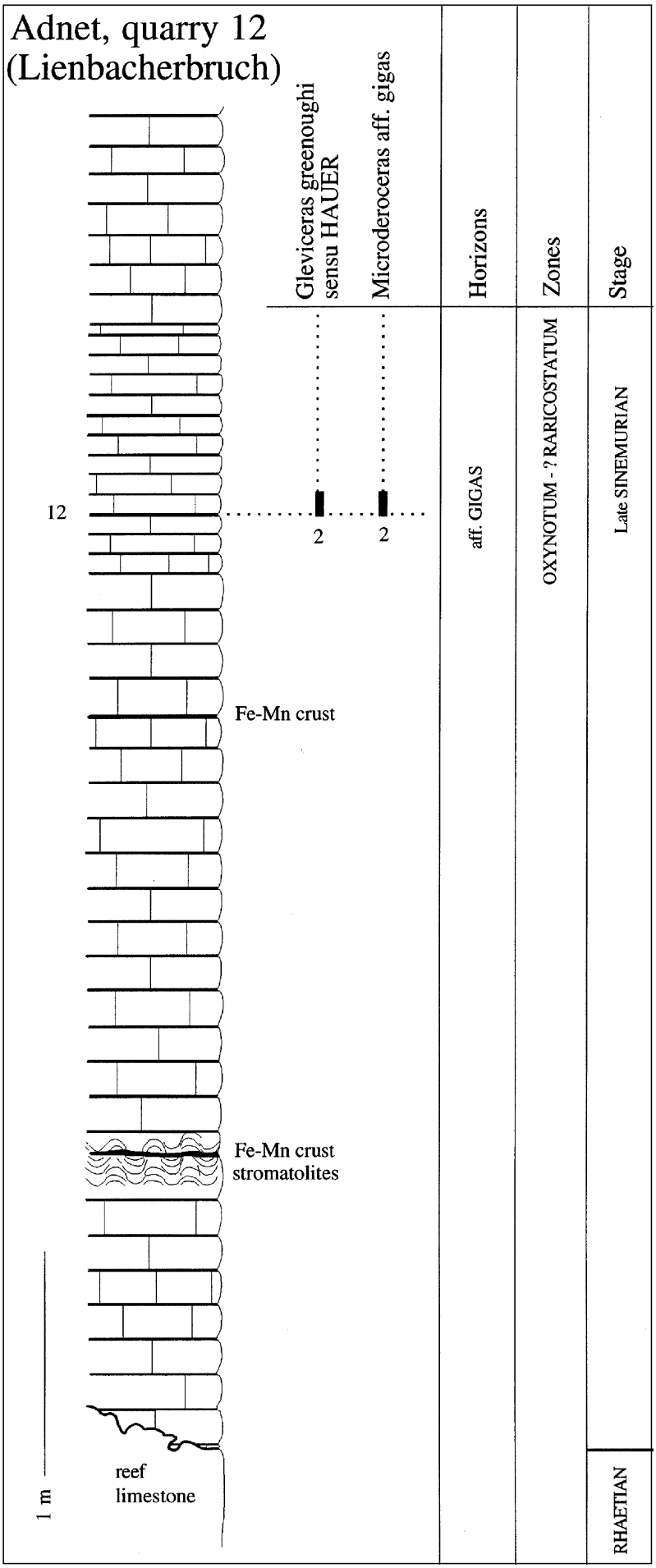
In most sections the base of the Liassic limestone series is formed by a few centimetres of condensed red limestone overlain by a ferromanganese crust of upper Hettangian age (WENDT, 1971; BÖHM, 1992a). Above the crust follows a series of red micritic, mostly nodular limestones, up to 13 m thick. They are erosively overlain by a thick debris flow deposit called Scheck breccia (BÖHM et al., in press).

The nodular limestones are known from sections in the surroundings to be of Sinemurian to Carixian age (MEISTER & BÖHM, 1993), but due to the erosion by the Scheck debris flows Carixian and uppermost Sinemurian are lacking in most Adnet quarry sections (BÖHM et al., in press). The nodular limestones of Adnet therefore belong to the Sinemurian Schmiedwirt Member of the Adnet Formation following the lithostratigraphy proposed by BÖHM et al. (in press) for the Osterhorn Mountains (Text-Fig. 2). We could not find the strongly marly nodular limestones of the overlying Kehlbach Member (Carixian), which are well exposed in sections north of the Adnet quarries. At Adnet we sampled the upper Hettangian ferromanganese crust and several levels of the



Text-Fig. 4.
Adnet (quarry 31, Rotgrauschnöllbruch; SW part) lithological profile and ammonite ranges.

Text-Fig. 5.
Adnet (quarry 12, Lienbacherbruch; NW part) lithological profile and ammonite ranges.



nodular limestones providing ammonite faunas. For the identification of individual quarries we refer to the numbers and quarry names of KIESLINGER (1964). Locations are shown in Text-Fig. 3. Details on the microfacies and regional situation of the Adnet area were recently given by BÖHM (1992a).

3.1.1. Quarry 31 (Rotgrauschnöllbruch)

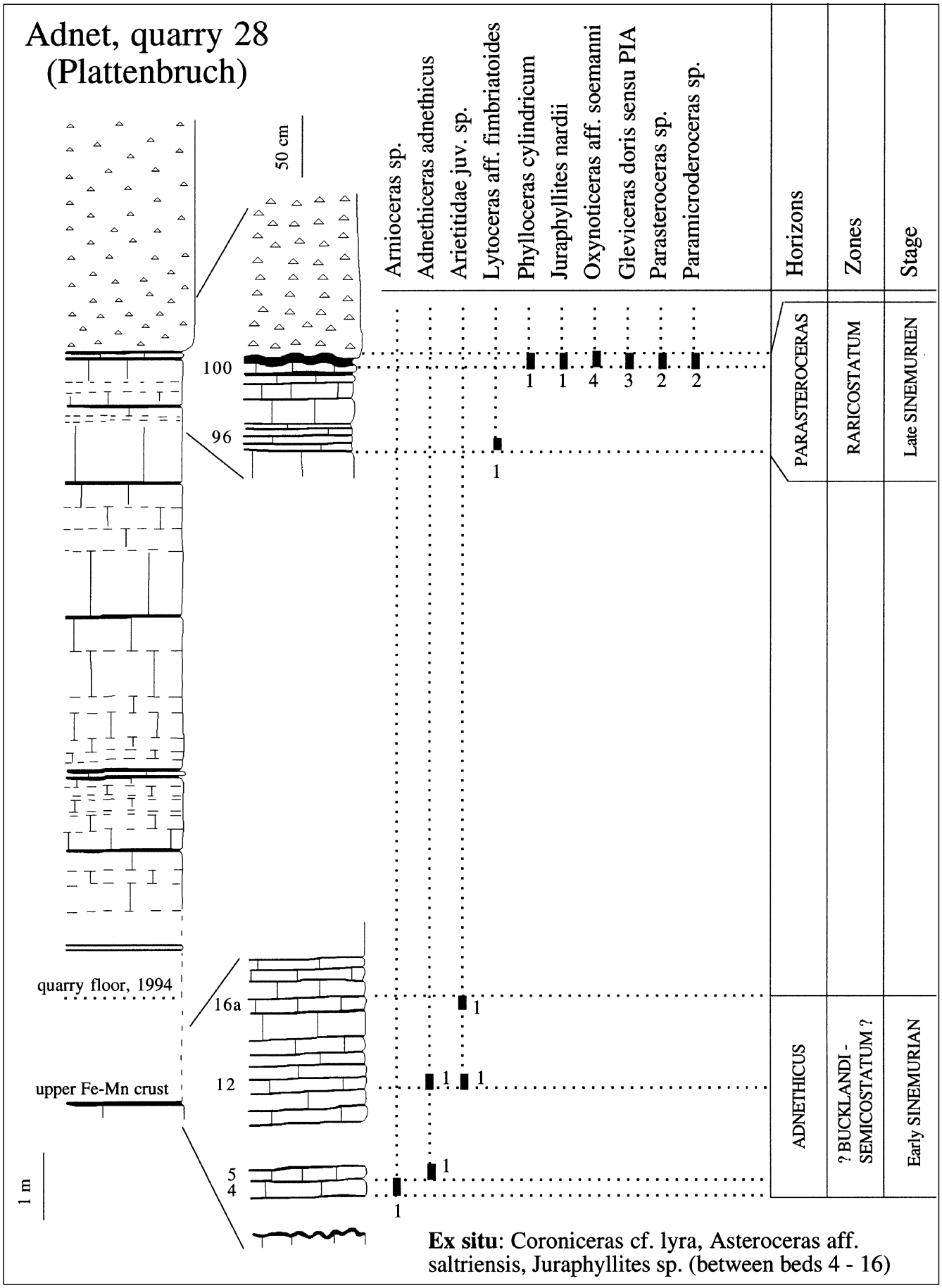
This quarry exposes the Upper Hettangian ferromanganese crust ("Brandschichte", GALLET et al., 1993: Text-Fig. 2). The quarry is still active. The section shown in Text-Fig. 4 was profiled in April 1993 in the southwestern corner of the quarry and has been cut away since then. The ferromanganese crust rests on about 1 m of massive red-grey crinoidal limestone of middle to upper Hettangian age (WÄHNER, 1886; GALLET et al., 1993), which thickens to several metres towards the north. All ammonites collected were embedded in the ferromanganese matrix. The crust is overlain by the red nodular limestones of the Adnet Formation with another ferromanganese crust and a horizon of deep-water stromatolites about half a metre above the Hettangian crust (BÖHM & BRACHERT, 1993).

The Upper Hettangian hardground can be found in many of the Adnet quarries, in many other localities of the Osterhorn block and even in other parts of the Northern Calcareous Alps (WENDT, 1971; BLOOS, 1988; BÖHM, 1992a). It forms a very useful marker bed in the Osterhorn Mountains and probably originated from submarine omission during a eustatic sea-level lowstand (BÖHM, 1992b).

3.1.2. Quarry 12 (Lienbacherbruch)

A special thick bedded facies of the Adnet Formation with few nodular layers and abundant encrusted intraclasts ("Hartgrundklasten", BÖHM, 1992a: 87) occurs near the top of the drowned Rhaetian Adnet reef. It is exposed in the active quarry 12. The section of Text-Fig. 5 was profiled in June 1992 in the northwestern part of the quarry. We found an ammonite-rich level in a slightly marly, thin-bedded layer resting on 4.7 m of decimetre-bedded red limestones. Overlying the marly layer 2–3 m of red limestones are exposed.

The upper Hettangian ferromanganese crust forms the base of the Liassic limestones (WENDT, 1971: Fig. 3). The marker layer of deep-water stromatolites, also found in quarry 31, lies about 3 m below our ammonite-rich level in this part of the quarry. GALLET et al. (1993) report *Arnioceras*, *Asteroceras* and *Oxynoticeras* from the lower part of the section.



Text-Fig. 6.
Adnet (quarry 28, Plattenbruch) lithological profile and ammonite ranges.
The section exposes thin-bedded red nodular limestones overlain by the Scheck breccia. Only major bedding planes are shown.

3.1.3. Quarry 28 (Kiefer-Plattenbruch)

This active quarry is situated in the northern part of the Adnet quarry area. It is the thickest Liassic section exposed at Adnet (Text-Fig. 6) with about 13 m of thin-bedded, slightly marly, nodular red Adnet Limestones of the Schmiedwirt Member (mainly MF6 of BÖHM, 1992a), disconformably overlain by a several metres thick "Scheck" breccia layer (Scheck Member). The erosive contact is clearly visible near the top of the sawn quarry wall.

The base of the nodular limestones is formed by a ferromanganese crust, which was exposed some years ago. Unfortunately, due to a fault between this exposure and the upper part of the section the exact position of the basal crust is unknown.

The nodular limestones of the Schmiedwirt Member show a bedding hierarchy, well visible on the sawn walls. Most beds are 5–15 cm thick with few exceptions of up to 0.5 m. Many of these beds have rather indistinct bedding planes, which may vanish laterally on a scale of some metres. The thin beds form packages of about 1 to 2.5 m thickness, bordered by major marly partings. Some of these packages show an internal organization with upward thinning and increasing nodularity. Seven packages are visible on the quarry wall (Text-Fig. 6).

3.1.4. Quarry 41 (Deislbruch) and Quarry 38 (Wolfgruberbruch)

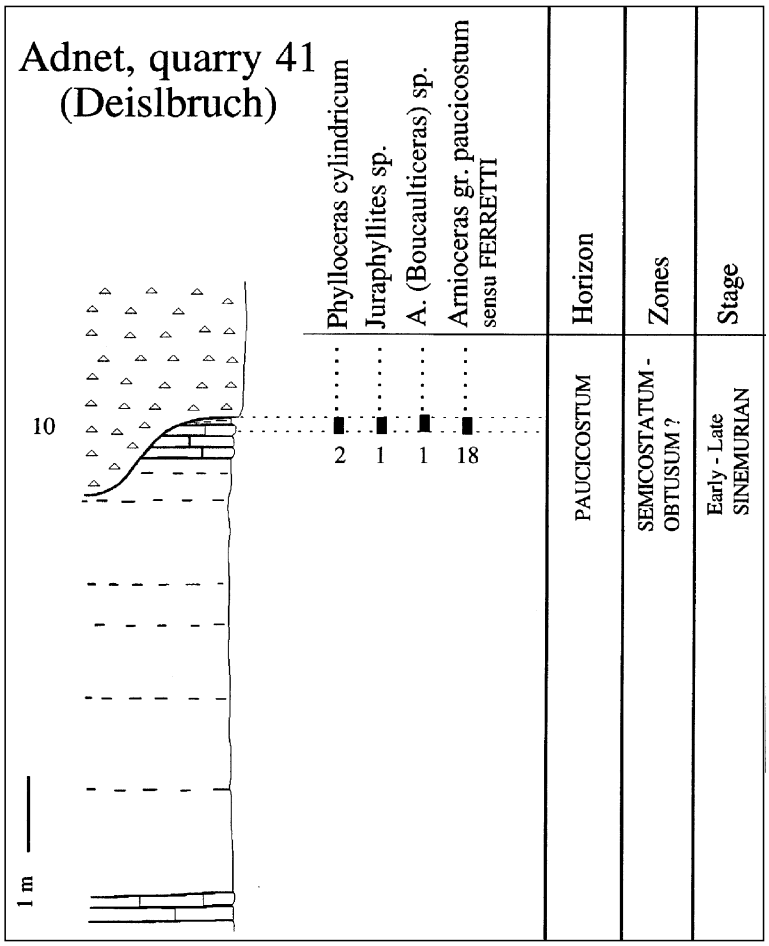
Both quarries are situated 1.5 km northeast of the village of Adnet near the Wolfgrub farmhouses. Quarry 41 (Text-Fig. 7) is still working, quarry 38 (Text-Fig. 8), which is situated about 100 m north of quarry 41, is abandoned.

Quarry 41 was described by WENDT (1971). It exposes the same slightly marly red nodular limestones (Schmiedwirt Mb.) seen in quarry 28. Again they are erosively cut by the overlying Scheck breccia (BÖHM et al., in press: Fig. 5). Compared to quarry 28 the thickness of the nodular limestones is reduced to only 7 m (41, central part), 8 m (41, NW part) and 10 m (quarry 38). Considering our biostratigraphic results, this can be explained by stronger erosion by debris flows.

The base of the nodular limestones is formed by the Upper Hettangian ferromanganese crust ("Brandschichte"), which from time to time becomes exposed on the floor of quarry 41 (WENDT, 1971). We found ammonites in the upper part of the nodular limestones, in a marl rich interval starting about 7 m above the basal crust.

3.2. Additional Outcrops of the Osterhorn Block

Two additional locations in the northern and southern part of the Osterhorn block were investigated to enlarge our data base. Both sections represent Liassic basinal settings. Both the Glasenbach and the Wetzsteingraben section show very complex tectonic structures due to intra-Jurassic gravity sliding. For the Wetzsteingraben the connection with the Tauglboden Formation allows to date the sliding as Late Jurassic. In the Glasenbach section the situation is less clear. Both Early and Late Jurassic ages or combinations of them are possible. Detailed biostratigraphy may help to solve this problem. Our results provide a first step.

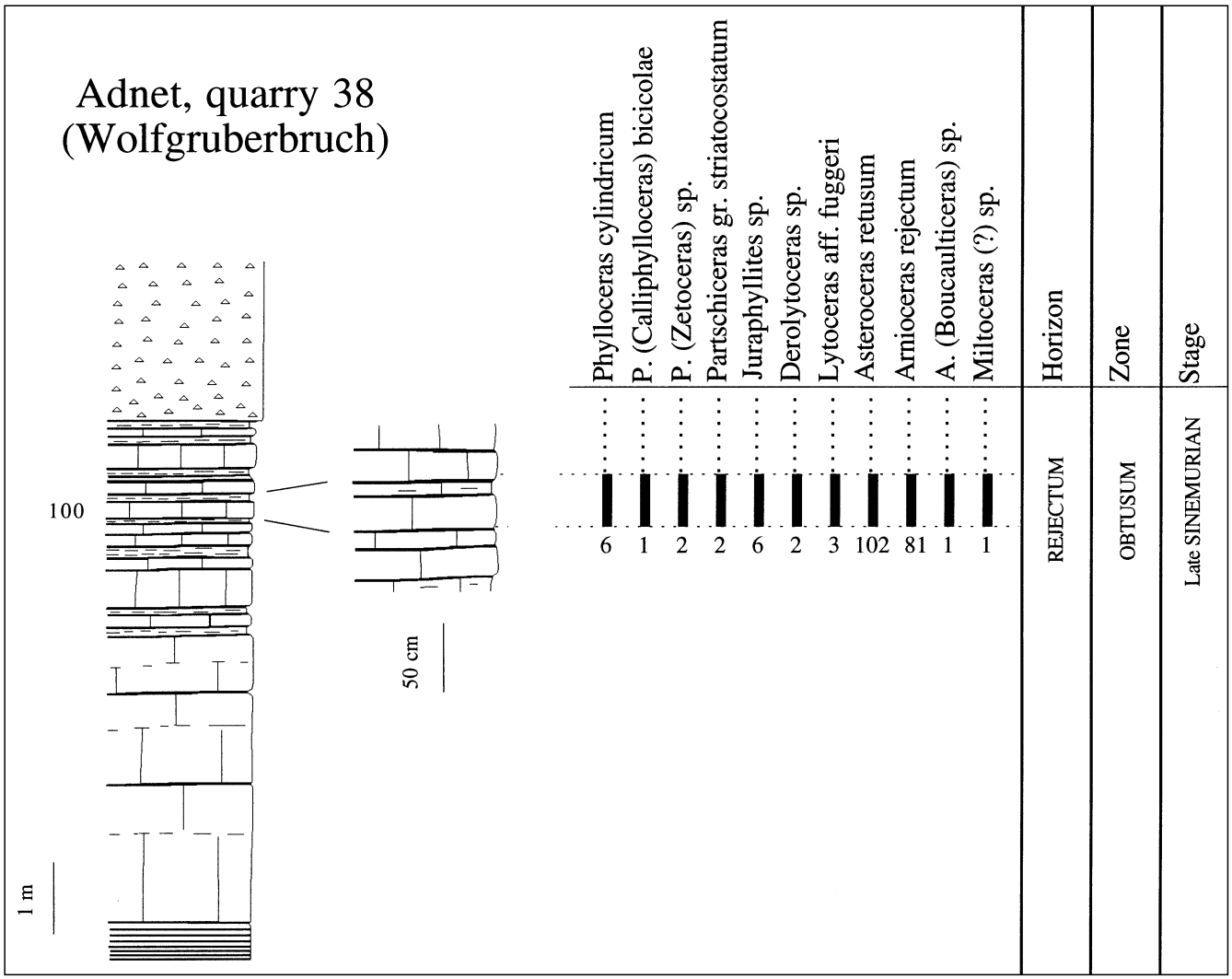


3.2.1. Glasenbach Gorge

The Glasenbach Gorge is situated 8 km north of Adnet, in the southeastern outskirts of the city of Salzburg (Text-Figs. 1, 9). There, in the northwestern part of the Osterhorn block, grey basinal limestones (Scheibelberg Fm., Text-Fig. 2) were deposited during the Sinemurian, while red limestones of the Adnet Formation formed in the Adnet area (BÖHM, 1992a: Fig. 62). The Glasenbach section displays the most basinal part exposed there.

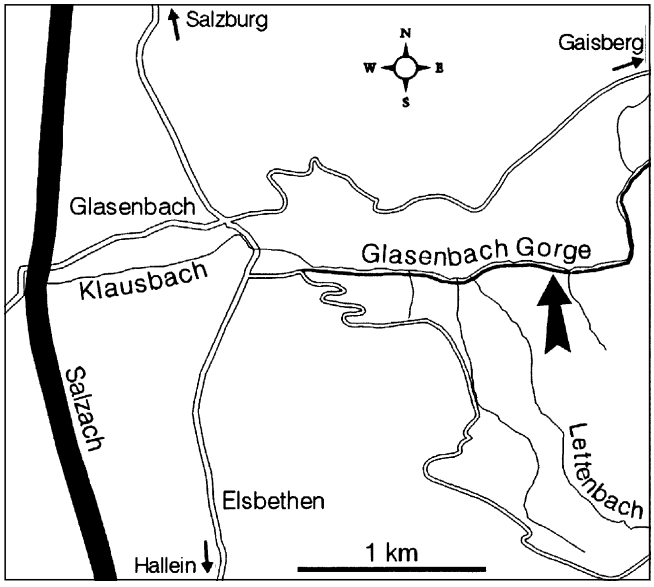
The gorge exposes more than 300 m of WNW dipping Sinemurian–Oxfordian sediments, unconformably overlain by an Upper Cretaceous conglomerate (Gosau) in the western part of the gorge (PREY, 1969). Sedimentary succession and tectonic structure were described in detail first by FUGGER (1906) and later by VORTISCH (1970) and BERNOULLI & JENKYNS (1970). Some short reports with additional information were provided by DEL-NEGRO (1958, 1979). We will give only a short description of the lower part of the exposed section, which is relevant for the stratigraphic context of the ammonite-bearing strata.

Text-Fig. 7.
Adnet (quarry 41, Deislbruch) lithological profile and ammonite ranges.
Thin-bedded red nodular limestones overlain by the Scheck breccia. Only major bedding planes are shown.



Text-Fig. 8.
Adnet (quarry 38, Wolfgruberbruch) lithological profile and ammonite ranges.
Thin-bedded red nodular limestones overlain by the Scheck breccia.

The section starts in the easternmost part of the gorge with grey limestones with darkgrey spots, ("Fleckenkalk").

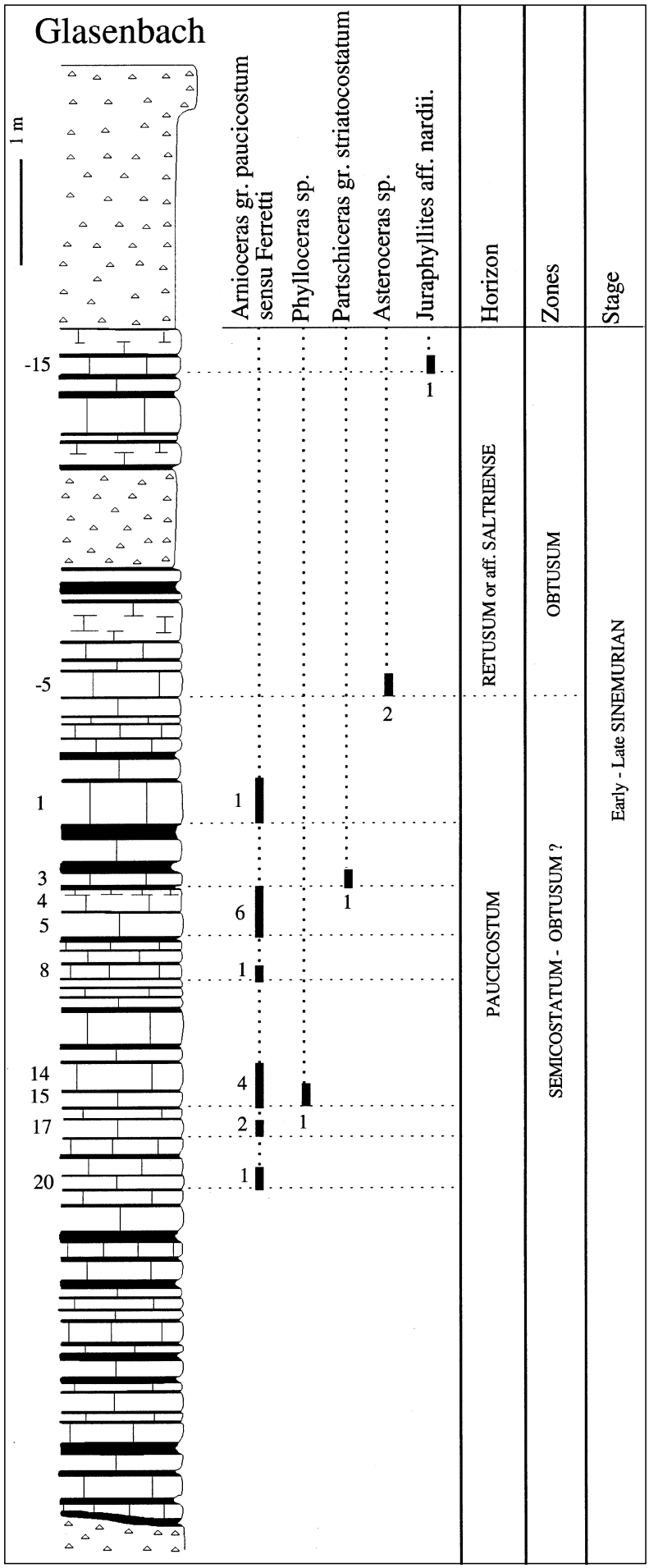


Text-Fig. 9.
Location of the studied section (arrow) in the river bed of the Klausbach in the Glasenbach Gorge.

VORTISCH (1970) and DEL-NEGRO (1979) relying on FUGGER (1906) mention *Arnioceras ceratitoides* (QUENSTEDT) and *Echioceras raricostatum* (ZIETEN) from this unit. It thus could comprise the Middle to Late Sinemurian.

A steep fault separates this unit from lightgrey cherty Scheibelberg limestone to the west. VORTISCH (1970) found *Arnioceras* near the top of this unit. The top is formed by a huge layer of slump masses (BERNOULLI & JENKYNS, 1970: Pl. 5/2) containing Hettangian sediments. BERNOULLI & JENKYNS (1970) interpreted this and other slump complexes of the section as synsedimentary mass flows.

The slump mass is overlain by grey slightly cherty limestones (Text-Fig. 10) similar to those found below. Another slump complex forms the upper boundary of this 12 m thick layer, which in it s middle third contains many ammonites. Above the upper slump mass some 10 m of Scheibelberg Limestone (Middle or Upper Sinemurian, VORTISCH, 1970) pass abruptly into red marly nodular limestones of the Adnet Formation (Kehlbach Member, Carixian). We investigated the 12 m thick limestone layer intercalated between the two slump masses (limestones left of "1B" in BERNOULLI & JENKYNS, 1970: Fig. 1). This unit is well exposed in the river bed, west of the ichtyosaur plaque. The limestones overlie the irregular surface of the lower slump masses (Text-Fig. 10). The contact is formed by some centimetres of black calcareous shale. The upper



Text-Fig. 10.
Glasenbach lithological profile and ammonite ranges. The section outcrops in the river bed west of the ichtyosaur plaque. The ammonite-rich grey limestones are intercalated between two slump masses.

slump mass overlying the limestones is a breccia with marly matrix and few lightgrey components. It s top is formed by a hard massive component-rich bed with a sparitic crinoidal matrix. The breccia can be seen to pass into slump masses above the road along the river.

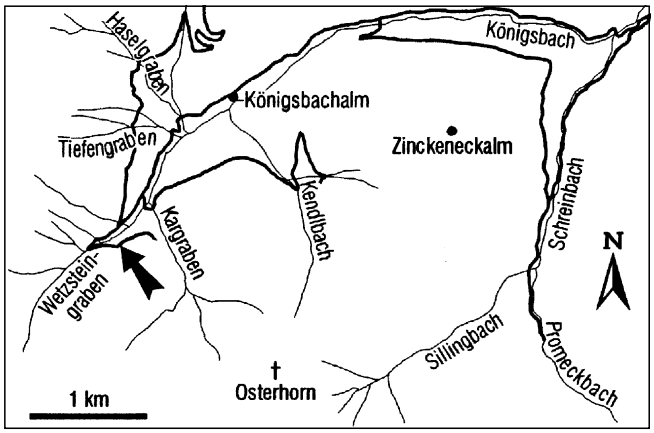
The limestones consist of 10 to 40 cm thick beds of lightgrey, partly greenish, bioturbated wackestones with ostracodes, sponge spicules and radiolarians (MF4, BÖHM, 1992a). Small violett-red spots occur occasionally. Bedding planes are due to grey marl partings of up to 5 cm. Rare thicker marl intervals (up to 15 cm) contain thin limestone layers. Ammonites occur on bedding planes and within the limestone beds. A 1 m thick marly breccia layer is intercalated near the top of the limestone unit.

According to BERNOULLI & JENKYNS (1970) the limestone unit should represent the normal autochthonous sedimentation between two intra-Sinemurian events of gravitational mass flows. On the other hand VORTISCH (1970) stressed the repetition of stratigraphic levels in the limestone units separated by the slump masses. The model of gravitational mass flows is largely accepted today. But, if VORTISCH was right, our limestone unit must represent a large allochthonous slide. Then, most of the grey limestones exposed in the Glasenbach gorge may be part of a large mass flow, that took place at the end of the Sinemurian as assumed by BÖHM (1992a), or alternatively, of an even much larger event of Early Toarcian or Late Jurassic age. Neither the stratigraphic data collected by VORTISCH (1970) nor the sedimentological data available at the moment allow to prove one of these possibilities. Bedding attitude below (275/20) and above (290/20) the upper slump mass are not significantly different.

3.2.2. Wetzsteingraben

The Wetzsteingraben is the most remote tributary of the Königsbach, situated in the eastern part of the Osterhorn block, 16 km east of Adnet (Text-Figs. 1, 11). It can be accessed from Abersee at the southern side of Lake Wolfgang. The Wetzsteingraben reaches the Königsbach some hundred metres southwest of the famous Kendlbachgraben (Rhaetian–Hettangian boundary).

We investigated an outcrop southeast of the creek at the forest road, which crosses the Wetzsteingraben at about 870 m. Short descriptions are given by PLÖCHINGER (1977,



Text-Fig. 11.
Location map for the Wetzsteingraben.
The studied section is located at the forest road east of the Wetzsteingraben (arrow).

1982: 65f). A very detailed but hardly readable description of the Wetzsteingraben is provided by VORTISCH (1960). We sampled a large olistolith of red Liassic marl and limestone (Adnet Fm.), very rich in ammonites, embedded in breccias and cherts of the Late Jurassic Tauglbodem Formation. The olistolith consists of red marls and red (rarely grey) limestone beds. Both show clear signs of strong bioturbation. Some burrows are discernible. Echinoderm content is rather low. The limestone beds are biomicrites (wackestones), some with ostracodes and sponge spicules (MF5, BÖHM, 1992a). Graded crinoidal turbidite beds with thin basal lithoclastic layers occur (MF25a, BÖHM, 1992a). Red crinoidal, strongly bioturbated marls with large burrows of Zoophycos outcropping to the right of the marly limestones did not yield ammonites.

PLÖCHINGER (1982) reported *Prodactylioceras* sp. from the ammonite-rich, red marly limestones pointing to a Pliensbachian age. He ascribed them to the Saubachschichten, a common Toarcian lithological unit of the Osterhorn Mountains (Saubach Mb, Text-Fig. 2).

The low echinoderm content of limestone beds and most marls, the lack of "filaments" (planktonic bivalves) as well as the frequent occurrence of sponge spicules contradict the assignment to the Saubach member sensu BÖHM et al. (in press). The high marl content, the presence of lithoclastic turbidites and the Pliensbachian age allow to assign these series to the Kehlbach member (Text-Fig. 2). There is also facial and stratigraphic correspondence to red marly limestones of middle Carixian to lower Domerian age, overlying grey basinal Fleckenmergel at the Rötelstein (MEISTER & BÖHM, 1993).

Several Liassic lithologies are found as olistoliths within the Upper Jurassic Tauglboden breccias of the Königsbach area. Large olistoliths of basinal grey Liassic Flekkenmergel are most common (VECSEI, 1986). The olistoliths are thought to have slided northward into the Late Jurassic Tauglboden basin (SCHLAGER & SCHLAGER, 1973) from a former basinal area at the southern rim of the Osterhorn block, transformed into the Trattberg high during late Jurassic (discussion in BÖHM, 1992a: 133, 147).

The stratigraphic succession of this Liassic basin probably was similar to that of the Rötelstein (MEISTER & BÖHM, 1993) with grey Fleckenmergel passing into red marly limestones during middle Carixian. The red facies probably lasted at least until the Toarcian. Very similar successions are found again in other Liassic basins: at the Rotkogel near Bad Ischl (SCHÄFFER & STEIGER, 1986; MEISTER & BÖHM, 1993) and about 150 km to the east at the Luftstraße section near Kirchberg (BÖHM, 1992a: 179). Obviously red facies occurred in many basinal areas during the early or middle Carixian. The occurrences are contemporary with an onset of increased tectonic activities in many parts of the Northern Calcareous Alps (BÖHM et al., in press).

The transition to red facies was caused by reduced sedimentation rates (MEISTER & BÖHM, 1993: Fig. 8). Reduced rates of sediment deposition in basinal settings may have resulted from:

1) A change in the patterns of sediment distribution by gravitational transport and currents.
2) Increased erosion by gravity flows.
3) Changes in subsidence patterns creating new sinks and thereby starving former ones.

4. Systematic Paleontology

Remark

This paper is a complement to the study of MEISTER & BÖHM (1993). Descriptions and discussions detailed there will not be repeated here. So, for the well-known taxa we refer the reader to MEISTER (1986, 1989), DOMMERGUES & MEISTER (1987 a/b, 1989 a/b, 1990a), MEISTER & LOUP (1989), DOMMERGUES et al. (1990, 1994), BLAU & MEISTER (1991), MEISTER & BÖHM (1993). The rich material collected in the Adnet quarries and new data on the Tethyan Sinemurian from the Central Apennine give us a better understanding of the variability of *Arnioceras* and *Asteroceras* and let us precise their systematic position. But with few exceptions the taxonomy agrees well with all our previous papers.

Suborder: Phylloceratina ARKELL 1950
Superfamily: Phylloceratacea ZITTEL 1884
Family: Phylloceratidae ZITTEL 1884
Subfamily: Phylloceratinae ZITTEL 1884
Genus: *Phylloceras* SUESS 1865

Type species: *Ammonites heterophyllus* SOWERBY 1820.

Phylloceras sp.

(Pl. 1, Fig. 1)

We regroup here a Hettangian Phylloceratid with a quite opened umbilicus (O/D≥12 %).

Local range: *marmorea* horizon, Hettangian–Sinemurian (Adnet quarry 31).

Phylloceras cylindricum (SOWERBY, 1833)

(Pl. 1, Fig. 3)

1833 *Ammonites cylindricum* SOWERBY, 1812–46, p. 333, Fig. 62.
1901 *Phylloceras cylindricum* (SOWERBY). – FUCINI, Pl. 2, Fig. 6–8.
1901 *Phylloceras cylindricum* var. *bielzii* HERB. – FUCINI, 1901–05, Pl. 3, Fig. 1–4.
1994 *Phylloceras cylindricum* (SOWERBY). – DOMMERGUES, FERRETTI & MEISTER, Pl. 1, Fig. 1–2.

We regroup here some Sinemurian *Phylloceras* characterized by parallel whorlsides and by low rounded venter. This morphology persists during all the ontogeny. This kind of morphology is also close to juvenile *P. (Hantkeniceras)* but in this subgenus the intermediate and adult whorl-sections become more inflated.

Local range: gr. *paucicostatum* horizon *Parasteroceras* sp. horizon (Early Sinemurian Late Sinemurian) [Adnet quarries 28, 38, 41].

Phylloceras gr. *frondosum – hebertinum* (REYNÈS 1868)

1868 *Ammonites Hebertinus* REYNÈS, Pl. 2, Fig. 3.
Ammonites frondosus REYNÈS, Pl. 5, Fig. 1.
1884 *Phylloceras Meneghinii* GEMMELLARO, Pl. 2, Fig. 13–17.
1989 *Phylloceras frondosum* (REYNES). – MEISTER, Pl. 2, Fig. 1, 2 with synonymy.
Phylloceras hebertinum (REYNES). – MEISTER, Pl. 2, Fig. 5, 7 with synonymy.
1993 *Phylloceras* gr. *frondosum* (REYNES). – MEISTER & BÖHM, Pl. 2, Fig. 1, 2.

Only one exemplar from Wetzsteingraben can be put close to the *P. frondosum – hebertinum* group. The fragmentary sample shows an intermediate morphology between the broad whorl section of *P. hebertinum* (REYNES) and the narrow one of *P. frondosum* (REYNES).

Local range: *algovianum* horizon, Margaritatus zone (Wetzsteingraben).

Subgenus: *Calliphylloceras* SPATH 1927

Type species: *Phylloceras disputabile* ZITTEL 1869.

P. (Calliphylloceras) bicicolae (MENEGHINI 1874)

(Pl. 1, Fig. 11)

1874 *Phylloceras Bicicolae* MENEGHINI, p. 106.
1989 *Calliphylloceras bicicolae* (MENEGHINI). – MEISTER, Pl. 2, Fig. 3, 4 with synonymy.
1993 *Calliphylloceras bicicolae* (MENEGHINI). – MEISTER & BÖHM, Pl. 1, Fig. 2, 5.

These strongly periodically constricted *Phylloceras* are attributed to the long range species *P. (C.) bicicolae* (MENEGHINI). If this species, even the genus, are well known during the Pliensbachian and the Toarcian, their distribution still stays episodic during the Sinemurian.

Local range: *rejectum* horizon isseli level (Obtusum Margaritatus zones) [Adnet quarry 38, Wetzsteingraben].

Subgenus: *Zetoceras* KOVÁCS 1939

Type species: *Ammonites zetes* d'ORBIGNY 1850.

P. (Zetoceras) sp.

(Pl. 1, Fig. 4)

We regroup here some Phylloceratina characterized by an involute shell, a compressed whorl section with slightly convergent sides towards the extern part, a narrow ventral area and a highly complex suture line.

Local range: *rejectum* horizon, Obtusum zone (Adnet quarry 38).

Genus: *Partschiceras* FUCINI 1923

Type species: *Ammonites Partschi* STUR 1851.

Partschiceras gr. *striatocostatum* (MENEGHINI 1853)

(Pl. 1, Figs. 9, 12)

1851 *Ammonites Partschi* STUR, p. 26 (nom. nudum).
1853 *Ammonites striatocostatus* MENEGHINI, p. 28.
1868 *Ammonites Sturi* REYNÈS, Pl. 3, Fig. 1.
1913 *Phylloceras anonynum* HAAS, Pl. 1, Fig. 5.
1977 *Partschiceras sturi* (STUR). – WIEDENMAYER, Pl. 2, Fig. 6, 7; Pl. 5, Fig. 1–4 with synonymy.
Partschiceras striatocostatum (MENEGHINI). – WIEDENMAYER, Pl. 4, Fig. 5–8 with synonymy.
1993 *Partschiceras striatocostatum* (MENEGHINI). – MEISTER & BÖHM, Pl. 2, Fig. 4 with synonymy.

We put in affinity with *P. striatocostatum* (MENEGHINI) several fragments of a compressed Phylloceratidae characterized in the adult stages by rectiradiate, blunt ribs and fine striae on the high part of the sides and on the venter.

An example from the lower part of the Late Sinemurian (Glasenbach) perhaps could be also brought near the MENEGHINI's species.

Local range: *rejectum* horizon algovianum level (Obtusum Margaritatus zones) [Adnet quarry 38, Glasenbach, Wetzsteingraben].

Family: Juraphyllitidae ARKELL 1950

Juraphyllitidae sp.

(Pl. 1, Fig. 2)

Some poorly preserved specimens can be attributed to the earlier members of that family. They come from the ferromanganese level near the base of the Adnet limestones at Adnet (*marmorea* horizon, Hettangian Sinemurian) (Adnet quarry 31).

Genus: *Juraphyllites* MÜLLER 1939

Type species: *Phylloceras diopsis* GEMMELLARO 1884.

Juraphyllites nardii (MENEGHINI 1853)

(Pl. 1, Fig. 6)

1853 *Ammonites Nardii* MENEGHINI, p. 27.
1866 *Ammonites transylvanicus* HAUER, p. 192.
1901 *Rhacophyllites nardii* (MENEGHINI). – FUCINI, Pl. 7, Fig. 1–7.
Rhacophyllites nardii var. *dorsocurvata* FUCINI, Pl. 8, Fig. 7.
1993 *Juraphyllites nardii* (MENEGHINI). – MEISTER & BÖHM, Pl. 2, Fig. 8, with synonymy.

The *Juraphyllites* regrouped here are characterized in the adult ontogenetic stages by well developed ribs from the lower part of the flank or at least from the periumbilicus edge.

Large Sinemurian specimens can attain a great size, more than 15 cm diameter.

Local range: *Parasteroceras* sp. horizon, Raricostatum zone (Adnet quarry 28, Glasenbach).

Juraphyllites libertus (GEMMELLARO 1884)

(Pl. 1, Fig. 5)

1884 *Phylloceras libertum* GEMMELLARO, Pl. 2, Fig. 1–5.
1977 *Juraphyllites libertus* (GEMMELLARO). – WIEDENMAYER, Pl. 1, Fig. 4; Pl. 3, Fig. 1, 2, 5.
1986 *Juraphyllites libertus* (GEMMELLARO). – MEISTER, Pl. 2, Fig. 8.
1986 *Juraphyllites libertus* (GEMMELLARO). – GAKOVIC, Pl. 2, Fig. 1.
1989 *Juraphyllites libertus* (GEMMELLARO). – MEISTER, Pl. 2, Fig. 9.
1990 *Juraphyllites* gr. *libertus* (GEMMELLARO). – DOMMERGUES & MEISTER, Fig. 3 (15).
1993 *Juraphyllites* gr. *libertus* (GEMMELLARO). – MEISTER & BÖHM, Pl. 3, Fig. 4.

One clearly constricted *Juraphyllites* from Wetzsteingraben is attributed to GEMMELLARO's species.

Local range: *isseli* level, Margaritatus zone (Wetzsteingraben).

Subgenus: *Harpophylloceras* SPATH 1927

Type species: *Ammonites eximius* HAUER 1854.

J. (Harpophylloceras) eximius (HAUER 1854)

(Pl. 1, Fig. 10)

1854 *Ammonites eximius* HAUER, Pl. 2, Fig. 1–4.
1977 *Harpophylloceras eximius* (HAUER). – WIEDENMAYER, Pl. 9, Fig. 6–13 with synonymy.
1989 *J. (Harpophylloceras) eximius* (HAUER). – MEISTER, Pl. 3, Fig. 1–3.

Constricted *Juraphyllites* characterized by a keel on the body chamber and by latero-ventral and ventral fine, prorsiradiate, close ribs.

Local range: Middle – Upper Carixian (Wetzsteingraben).

Suborder: Lytoceratina HYATT 1889
Superfamily: Lytoceratacea NEUMAYR 1875
Family: Lytoceratidae NEUMAYR 1875
Genus: *Adnethiceras* WIEDMANN 1970

Type species: *Ammonites Adnethicus* HAUER 1854.

Adnethiceras adnethicus (HAUER 1854)

(Pl. 2, Figs. 1, 6)

1854a *Ammonites Adnethicus* HAUER, p. 748.
1854b *Ammonites Adnethicus* HAUER, Pl. 1, Fig. 1–3.
1970 *Adnethiceras adnethicus* (HAUER). – WIEDMANN, Pl. 8, Fig. 1; Text-Fig. 25 with synonymy.
1994 *Adnethiceras adnethicum* (HAUER). – RAKUS, Pl. 4, Fig. 3.

The specimens here considered are Lytoceratids characterized by strong massive spaced subradiate ribs which cross the venter. Each rib bears a tubercle on the ventro-lateral part and between them, on the venter, the rib intensity shows little decrease. The whorl section is rounded.

Until now four species have been described, perhaps five if we take in account (?) *A. simplex* (VADASZ 1908). The differences between them are inconsistent, concerning mainly rib density, whorl section and tubercles.

Taking in account the rib density *A. adnethicum* (HAUER) presents an intermediate morphology between *A. ferstli* (HAUER), a more spaced ribbed form (HAUER 1854, Pl. 2), and *A. herbichi* (BONARELLI), a closer ribbed form. Moreover *A. haueri* WIEDMANN has a more oval whorl section and a second row of little tubercles situated near the lower part of the sides.

As shown by WIEDMANN (1970, p. 997), these Lytoceratidae present transitional morphologies between Ectocentritidae, any *Tragolytoceras* for ornamentation and Lytoceratidae mainly for the shell coiling and the whorl section.

Local range: Near the bottom of Quarry No 28 close to the upper ferromanganese level (*adnethicus* level, ? Bucklandi or ? Semicostatum zones) [Adnet quarry 28].

Genus: *Lytoceras* SUESS 1865

Type species: *Ammonites fimbriatus* SOWERBY 1817.

Lytoceras aff. *fuggeri* GEYER 1893

1893 *Lytoceras fuggeri* GEYER, Pl. 8, Fig. 7–9.
1909 *Lytoceras fuggeri* GEYER. – ROSENBERG, Pl. 11, Fig. 23, 24.
1994 *Lytoceras* gr. *fuggeri* GEYER. – DOMMERGUES, FERRETTI & MEISTER, Pl. 1, Fig. 13–16.

We regroup here inner moulds of Sinemurian *Lytoceras*. There are typical *Lytoceras* with rather evolute conch with very weak overlapping and bearing constrictions. Ornamentation is completely missing. Thus, confusions are possible between e.g. *L. fimbriatum* (SOWERBY), *L. fimbriatoides* (GEMMELLARO) and *L. fuggeri* GEYER. The specific determination is only founded on the presence of constrictions which show a clearly rursiradiate orientation equivalent to the one that characterizes the type of *L. fuggeri* GEYER.

Local range: *rejectum* horizon, Obtusum zone (Adnet quarry 38).

Lytoceras aff. *fimbriatoides* GEMMELLARO 1884

1884 *Lytoceras fimbriatoides* GEMMELLARO, Pl. 3, Fig. 20–23.
?1909 *Lytoceras* sp. nov. aff. *fimbriatoides* GEMMELLARO. – ROSENBERG, Pl. 11, Fig. 13.
?1913 *Lytoceras* sp. nov. aff. *fimbriatoides* GEMMELLARO. – HAAS, Pl. 2, Fig. 1, 2.
1942 *Lytoceras fimbriatoides* GEMMELLARO. – KOVÁCS, Pl. 2, Fig. 19.
1975 *Lytoceras fimbriatoides* GEMMELLARO. – FERRETTI, Pl. 24, Fig. 1, 2.
1994 *Lytoceras* aff. *fimbriatoides* GEMMELLARO. – DOMMERGUES, FERRETTI & MEISTER, Pl. 2, Fig. 1–4.

The constrictions and the ribs of this *Lytoceras* are less rursiradiate than in *L. fuggeri* GEYER. Moreover the ribs tend to be clearly subdivided toward the extern part of the whorls. The considered specimen is close to the Italian forms.

Local range: *Parasteroceras* sp. horizon, Raricostatum zone (Adnet quarry 28).

Genus: *Derolytoceras* ROSENBERG 1909

Type species: *Ammonites lineatus tortus* QUENSTEDT 1885.

Derolytoceras sp.

(Pl. 2, Figs. 2, 3)

Two small fragments of Lytoceratidae body chamber are characterized by strong, subannular, well prominent on the ventral area, rursiradiate ribs which strongly suggest *Derolytoceras*. They probably represent the microconch of the co-occuring *Lytoceras*, here *L.* aff. *fuggeri* GEYER.

Local range: *rejectum* horizon, Obtusum zone (Adnet quarry 38).

Suborder: Ammonitina HYATT 1889
Superfamily: Psiloceratacea HYATT 1867
Family: Schlotheimiidae SPATH 1923
Genus: *Schlotheimia* BAYLE 1878

Type species: *Ammonites angulatus* SCHLOTHEIM 1829.

Schlotheimia marmorea (OPPEL 1862)

(Pl. 2, Figs. 4, 7–9; Pl. 3, Figs. 1, 2)

1856 *Ammonites Charmassei* d'ORBIGNY. – HAUER, Pl. 14, Fig. 1–3.
1862 *Ammonites marmoreus* OPPEL, p. 130.
1963 *Schlotheimia marmorea* (OPPEL). – BLIND, Pl. 2, Fig. 5.
1963 *Schlotheimia (Angulaticeras) curvata* BLIND, Pl. 1, Fig. 23.
1963 *Schlotheimia (Angulaticeras) harpicostata* BLIND, Pl. 1, Fig. 19.
1988 *Angulaticeras marmoreum* (OPPEL). – BLOOS, Pl. 1–3; Pl. 4, Fig. 7, 8; Pl. 5–8; Pl. 9, Fig. 1 with synonymy.
1990 *Schlotheimia marmorea* (OPPEL). – GUERIN-FRANIATTE, Pl. 18, Fig. 3.

BLOOS (1988, p. 6) gives an excellent description of this species. The holotype was collected by HAUER from the ferromanganese layer ("Brandschichte") at the base of Adnet Limestone in a quarry of Adnet area. According to BLOOS this Alpine Schlotheimiidae fauna tends to present earlier during the ontogeny a narrower whorl section and an acute venter than their Southwest Germany equivalents. But contrarily to BLOOS we still prefer to rather attribute this species to the genus *Schlotheimia* than to *Angulaticeras*, because OPPEL's species does not show any furrow on the venter in the pre-adult and adult stages. Only the inner whorls show a little furrow which is a paedomorphic feature. Moreover for us the QUENSTEDT's genus *Angulaticeras* (type species: *Ammonites lacunatus* BUCKMAN) includes more involute and more recent forms, in other words more "derived" morphologies.

Our samples also are very close to the *A. charmassei* (d'ORBIGNY) but they have a wider, less steep, umbilicus and mainly present a more rounded elliptical whorl section.

Local range: *marmorea* horizon (Angulata to Bucklandi zones ?) [Adnet quarry 31].

Genus: *Angulaticeras* QUENSTEDT 1883

Type species: *Ammonites lacunatus* BUCKMAN 1844.

Subgenus: *Boucaulticeras* SPATH 1924

Type species: *Ammonites boucaultianus* d'ORBIGNY 1844.

Angulaticeras (Boucaulticeras) sp.

(Pl. 2, Fig. 5)

cf. 1990 *Angulaticeras (Boucaulticeras)* sp. DOMMERGUES, MEISTER & METTRAUX, Pl. 2, Fig. 1.

Fragment of a small involute Schlotheimiidae with very fine close ribbing. They come from the level with *Arnioceras paucicostatum* sensu FERRETTI no FUCINI and from the level with the *Asteroceras*.

Local range: gr. *paucicostatum* horizon – *rejectum* horizon (? Semicostatum – Obtusum zones) [Adnet quarries 38, 41].

Family: Arietitidae HYATT 1875

Arietitidae ssp.

(Pl. 3, Figs. 6, 7, 9)

We have here gathered several ammonites which come from the ferromanganese level of Adnet (*marmorea* horizon, Late Hettangian or Early Sinemurian, quarry 31) and from the base of the overlying red Limestone sequence (*adnethicus* level, Early Sinemurian). Some are illustrated in the iconographical part (Pl. 3, Figs. 6, 7, 9).

Subfamily: Alsatitinae HYATT 1875
Genus: *Pseudaetomoceras* SPATH 1923

Type species: *Arietites abnormilobatus* WÄHNER 1886.

Pseudaetomoceras abnormilobatus (WÄHNER) 1886

(Pl. 3, Figs. 3, 8)

1886 *Arietites abnormilobatus* WÄHNER, Pl. 23 (38), Fig. 4–7.

Medium involute small sized ammonite with compressed whorl section and very sharp and high keel. The ribs are simple, straight and slightly rursiradiate on the flanks, thicker at the ventro-lateral edge and going forward on the ventral part.

Local range: *marmorea* horizon (Angulata or Conybeari zones) [Adnet quarry 31].

Subfamily: Arietitinae HYATT 1875
Genus: *Paracaloceras* SPATH 1923

Type species: *Ammonites coregonensis* SOWERBY 1831.

Paracaloceras aff. *grunowi* (HAUER 1856)

(Pl. 3, Fig. 5)

1856 *Ammonites Grunowi* HAUER, Pl. 8, Fig. 5, 6.
1879 *Ammonites grunowi* HAUER. – REYNES, Pl. 31, Fig. 15, 17.
1888 *Ammonites grunowi* HAUER. – WÄHNER, Pl. 44, Fig. 2, 3.
1908 *Arietites* sp. indet aff. *grunowi* HAUER. – DIENER, Pl. 16, Fig. 3.
1990 *Paracaloceras* cf. *grunowi* HAUER. – TAYLOR, Pl. 1, Fig. 1, 2; Pl. 2, Fig. 1.
1994 *Paracaloceras grunowi* HAUER. – RAKUS, Pl. 3, Fig. 3.

Evolute Arietitinae characterized by a strongly depressed whorl section and a weakly bisulcate venter with a wide but weak keel. The simple ribbing is gently concave and subradiate; on the venter, ribs are projected forward and fade toward the sulci. Our specimen closely agrees with WÄHNER's illustration and can also be put near the North American specimen of TAYLOR (1990) which are a little more coarsely ribbed.

Local range: *marmorea* horizon (Angulata or Conybeari zones) [Adnet quarry 31].

Genus: *Coroniceras* HYATT 1867

Type species: *Ammonites kridion* ZIETEN 1830 (ICZN opinion 324).

Coroniceras cf. *lyra* HYATT 1889

(Pl. 3, Fig. 13)

1879 *Ammonites multicostatus* SOWERBY. – REYNES, Pl. 24, Fig. 21–22 only.
1889 *Coroniceras lyra* HYATT, Pl. 4, Fig. 6–7; Pl. 5, Fig. 1–3.
1889 *Coroniceras lyra* HYATT var. A, Pl. 4, Fig. 1, 8, 12–14.
1889 *Coroniceras lyra* HYATT var. B, Pl. 4, Fig. 2–5.
1889 *Coroniceras lyra* HYATT var. C, Pl. 4, Fig. 9–11, 15, 16.
1966 *Coroniceras lyra* HYATT. – GUERIN-FRANIATTE, Pl. 22; Pl. 25; Pl. 26, Fig. 1–3; Pl. 27; Pl. 28.
1984 *Coroniceras lyra* HYATT. – CORNA, Pl. 7, Fig. 1.
1989 *Coroniceras* aff. *lyra* HYATT. – MEISTER & LOUP, Pl. 2, Fig. 7; Pl. 3, Fig. 2; Pl. 4, Fig. 2.

It is only a fragment of an evolute phragmocone characterized by a thick subtrapezoidal whorl section as broad as high, subradiate strong ribs bearing unconspicuous latero-ventral tubercles, less convex and nearly tricarinate venter with two large but shallow sulci. From the tubercles and toward the lateral keels, ribs are attenuated and weakly projected forward. This feature carries out to put the considered ammonite near late *Coroniceras* of the Semicostatum zone like *Coroniceras lyra* HYATT rather than to old *Coroniceras* of the Bucklandi zone.

Local range: cf. *lyra* level, Semicostatum zone (Adnet quarry 28).

Genus: *Arnioceras* HYATT 1867

Type species: *Arnioceras cuneiforme* HYATT, 1867.

Arnioceras gr. *paucicostum* sensu FERRETTI 1975 non FUCINI 1902

(Pl. 3, Fig. 11; Pl. 4, Figs. 1, 5)

non 1901–05 *Arnioceras ceratitoides* var. *paucicosta* FUCINI, Pl. 18, Fig. 9, 10, 12–14.
1975 *Arnioceras ceratoides paucicosta* FUCINI. – FERRETTI, Pl. 22, Fig. 1–3.
1993 *Arnioceras* gr. *mendax* var. *rariplicatum* FUCINI. – MEISTER & BÖHM, Pl. 4, Fig. 4.
1994 *Arnioceras* gr. *paucicosta* sensu FERRETTI non FUCINI. – DOMMERGUES, FERRETTI & MEISTER Pl. 2, Fig. 9–12.
? 1994 *Arnioceras* gr. *ceratitoides* (QUENSTEDT). – RAKUS, Pl. 5, Fig. 1.

These forms constitute the first acme of the *Arnioceras* in the studied area. Following DOMMERGUES et al. (1994), we regroup in *A.* gr. *paucicostatum* sensu FERRETTI these *Arnioceras* which present a great intraspecific variability in rib density and in whorl-section and which can attain a relatively large size (D = 120 mm). Ribs are rather acute and rigid and juvenile smooth stage quite short. In the Adnet area, these *Arnioceras* are characterized by a low rib density and thus are very close to the Subbriançonnais *Arnioceras*: *A.* cf. *mendax* var. *rariplicata* FUCINI sensu DOMMERGUES et al. (1990). This latter FUCINI's name was previously used to gather Austrian ammonites (MEISTER & BÖHM, 1993). But as assumed by DOMMERGUES et al. (1994) almost all the *Arnioceras* described in FUCINI (1901–1905), more than 25 species or varieties, are coming from 2 beds of the Monte di Cetona and must be regrouped in only one species with a large variability.

Local range: gr. *paucicostatum* horizon, ? Semicostatum – Obtusum zones (Adnet quarry 41, Glasenbach).

Arnioceras rejectum FUCINI 1902

(Pl. 3, Figs. 12, 14–16; Pl. 4, Fig. 2–4)

1902 *Arnioceras rejectum* FUCINI, Pl. 17, Fig. 14; Pl. 19, Fig. 1–6.
1993 *Arnioceras* gr. *ceratitoides* (QUENSTEDT). – MEISTER & BÖHM, Pl. 4, Fig. 3, 5, 6, 10.
1994 *Arnioceras rejectum* FUCINI. – DOMMERGUES, FERRETTI & MEISTER Pl. 2, Fig. 13–17.

These ammonites form the second acme of *Arnioceras* and they are associated with *Asteroceras*. They also show a large variability and the morphological differences, essentially in rib density, with the underlying *A.* gr. *paucicostatum* sensu FERRETTI are little. Indeed *A. rejectum* FUCINI presents globally a closer ribbing. New data from the Apennines (DOMMERGUES et al., 1994) carry out to attribute these Adnet forms, previously attributed to *A. ceratitoides* (QUENSTEDT), to *A. rejectum* FUCINI (MEISTER & BÖHM, 1993). In some samples, the smooth juvenile stage can reach 8 mm of diameter.

Local range: *rejectum* horizon, Obtusum zone (Adnet quarry 38).

Subfamily: Asteroceratinae SPATH 1946
Genus: *Caenisites* BUCKMAN 1925

Type species: *Caenisites caeneus* BUCKMAN 1925.

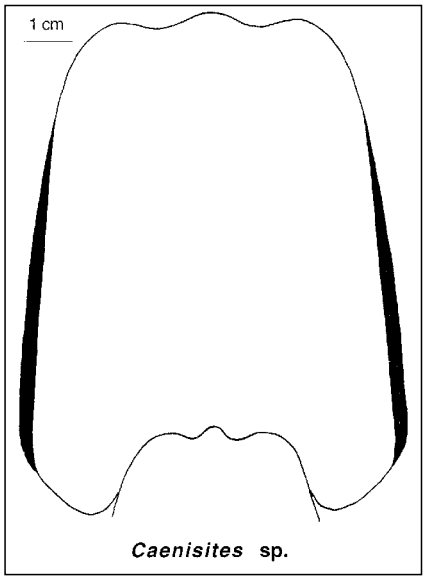
Caenisites sp.

We bring near to BUCKMAN's genus a rather involute (U/D = 0,33) and large Asteroceratinae (D = 350 mm). It is characterized by a wide tricarinate-bisulcate venter, still well developed on the body chamber. The ribs are strong, spaced and subradiate; on the body chamber they disappear at the middle of the flank and the extern part becomes smooth; only the tricarinate venter persists.

This ammonite cannot be brought near any nowadays known *Caenisites*. Only *C. brooki* (SOWERBY) presents a similar umbilicus which is the narrowest for the genus, but the ornamentation is very different and the whorl section of the alpine ammonite is more compressed than in SOWERBY's species (Text-Fig. 12).

By comparison *Eparietites* shows a clearly narrower umbilicus and the whorl section is more compressed and triangular with a fastigate venter because of the disappearance of the sulci.

Local range: *Caenisites* sp. level, Turneri zone (Adnet).



Text-Fig. 12.
Caenisites sp. whorl section.
Scale = 10 cm.

Genus: *Asteroceras* HYATT 1867

Type species: *Ammonites stellaris* SOWERBY, 1815.

Asteroceras gr. *retusum* (REYNES) sensu SACCHI-VIALLI & CANTALUPPI 1961 non REYNES 1879

(Pl. 4, Figs. 6–10; Pl. 5, Figs. 1–10)

1961 *Asteroceras retusum* REYNES. – SACCHI-VIALLI & CANTALUPPI, Pl. 4, Fig. 1–4.
?1961 *Asteroceras confusum* SPATH. – SACCHI-VIALLI & CANTALUPPI, Pl. 4, Fig. 5.
1993 *Asteroceras* aff. *confusum* SPATH. – MEISTER & BÖHM, Pl. 4, Fig. 7, 9, 11.

Evolute *Asteroceras* characterized by a subrectangular whorl-section with a large nearly tricarinate ventral area bearing well developed and broad sulci and a prominent and narrow keel. Moreover the transition between sides and the sulci is very steep. The sides are slightly convex and subparallel. The ribs are prorsiradiate and conspicuous until the ventro-lateral part, even at the adult stage. *A. margaritatoides* SPATH is a close species, as shown in SPATH's type (1926, Pl. 10, Fig. 5) but, at least in the inner whorls, the rib density is higher. The ventro-lateral edge is more convergent toward the venter and the transition is less abrupt. By comparison with the Saltrio fauna, our samples present, on the whole, a more compressed whorl-section and the sulci and keel seem slightly crenulated.

In *Asteroceras varians* FUCINI, the ornamentation disappears near the extern part and the ventral area is narrower. The sulci are less developed (CECCA et al., 1987) and the umbilicus smaller.

The numerous well preserved *Asteroceras* from Adnet show a great homogeneity in their morphology and allow us to regroup the major part of the *Asteroceras* from Breitenberg and Schmiedwirt under the specific name *A.* gr. *retusum* (REYNES) sensu SACCHI-VIALLI & CANTALUPPI.

Local range: *rejectum* horizon, Obtusum zone (Adnet quarry 38). *A. margaritatoides* SPATH and probably *A. retusum* (REYNES) sensu SACCHI-VIALLI & CANTALUPPI indicate the lower part of Stellare subzone (DOMMERGUES et al., 1994).

Asteroceras aff. *saltriensis* (PARONA 1896)

(Pl. 5, Fig. 11)

1896 *Arietites saltriensis* PARONA, Pl. 8, Fig. 2, 3.
1903 *Asteroceras saltriensis* (PARONA). – FUCINI, Pl. 33, Fig. 4–6.
?1994 *Asteroceras obtusum* (SOWERBY). – RAKUS, Pl. 5, Fig. 3.

The specimen collected ex situ, shows a clearly "derived" morphology charaterized by the disappearance of the sulci, replaced by two flat and smooth slopes on both sides of the keel. The ribs are strong, slightly arched, going forward on the ventro-lateral edge. "*A.*" *blakei* SPATH is a close form still more "derived" where the ribbing cross over the venter in the adult morphology. This type of morphology already suggests the genus *Aegasteroceras*.

Local range: aff. *saltriensis* level, Obtusum zone. Such forms indicate the middle to upper Stellare subzone (Adnet quarry 28).

Genus: *Epophioceras* SPATH 1924

Type species: *Ammonites landrioti* d'ORBIGNY, 1850.

Remark: The systematic position of the genus *Epophioceras* is still in discussion: Asteroceratid or Echioceratid (SCHLATTER, 1984). The simplicity of the morphological characters in this ammonite and mainly the simple suture line make difficult a definitive position.

Epophioceras deciduum (HYATT 1867)

(Pl. 6, Figs. 1, 3)

1856 *Ammonites nodotianus* d'ORBIGNY. – HAUER, Pl. 6, Fig. 1–3.
1867 *Ophioceras deciduum* HYATT, p. 76 (new name for the preceding).
1925 *Pleurechioceras deciduum* (HYATT). – TRUEMAN & WILLIAMS, p. 719.
1958 *Echioceras* cf. *deciduum* (HYATT). – DONOVAN, p. 17, Text-Fig. 3 with synonymy.
1973 *Echioceras deciduum* (HYATT). – GETTY, Pl. 3, Fig. 2.

The generic attribution of *O. deciduum* HYATT remains tentative. Although our samples agree with HYATT's species, two genera are proposed in the recent literature: *Epophioceras* or *Echioceras*. The evolute coiling shell, the prorsiradiate ribbing, the sustained subcircular whorl section, slightly higher than thick (Text-Fig. 3 in DONOVAN, 1958), the quite large groove on both sides of the keel characterize the first genus. With *Echioceras deciduum* (HYATT) shares very coarse and distant ribs. Even in the diagramm of GETTY (1973, Fig. 3) about the Echioceratidae, *E. deciduum* (HYATT) occupies an marginal position which underlines the originality of this species.

In the present paper, we follow the classic systematic position (DONOVAN et al., 1981) and we attribute *E. deciduum* (HYATT) to the genus *Epophioceras* mainly to take in account the rib ontogeny. Indeed the ribs are relatively close in the inner whorl and they become progressively distant during the ontogeny. Whereas in the *Echioceras* this changing is more sudden.

By comparison *E. landrioti* (d'ORBIGNY) has a less prominent keel, closer and less prorsiradiate ribs. The whorl section is broader. *E. longicella* (QUENSTEDT) presents closer ribs and a broader whorl section too.

Local range: Obtusum zone (Adnet quarry 28 and Museum of Adnet).

Genus: *Eparietites* SPATH 1924

Type species: *Arietites tenellus* SIMPSON in BUCKMAN 1912.

Eparietites glaber GUERIN-FRANIATTE 1966

(Pl. 7, Fig. 1)

1966 *Eparietites glaber* GUERIN-FRANIATTE, Pl. 198, Fig. 1, 2.
1990 *Eparietites* aff. *glaber* GUERIN-FRANIATTE. – DOMMERGUES, MEISTER & METTRAUX, Pl. 198, Fig. 1, 2.

The specimen here considered is characterized by a rather short juvenile ornamented stage and a rather subfastigate ventral area with two still well developed flat bands. In our specimen (D = 85 mm) the rather close ribbed stage seems to end at about 30 mm (alteration ?). The holotype (GUERIN-FRANIATTE, 1966) shows a longer ornamented stage. In *E. undaries* (QUENSTEDT), it is still longer. The "subbriançonnais" population (DOMMERGUES et al., 1990) presents a more acute (less shouldered) ventral part; the flat bands are less deep and always more oblique and the oxycone morphology is clearly expressed. *E. collenoti* (d'ORBIGNY) is an extreme form toward the oxycone morphology and the loss of the ornamentation.

Local range: Obtusum zone (Museum of Adnet).

Genus: *Parasteroceras* DOMMERGUES, FAURE & PEYBERNES 1986

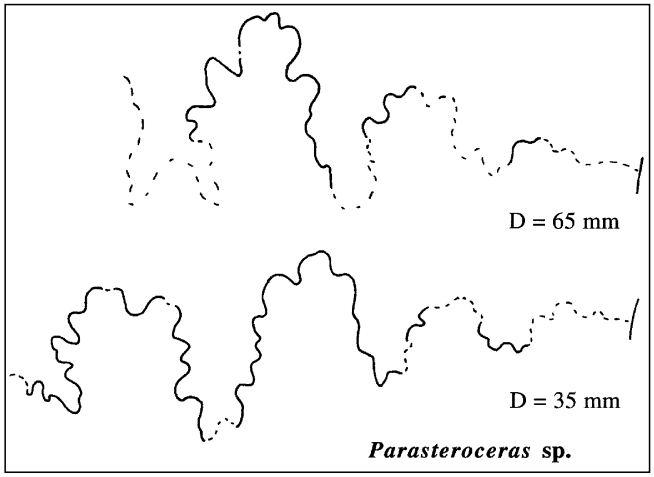
Type species: *Parasteroceras rakusi* DOMMERGUES, FAURE & PEYBERNES 1986.

Parasteroceras sp.

(Pl. 6, Fig. 2; Pl. 7, Fig. 2; Pl. 8, Fig. 1)

For the genus *Parasteroceras* our specimens are compressed and very oxycone. But if the venter is acute, the umbilicus is rather open. The steep umbilical wall is bordered by an angular umbilical edge.

Although the ornamentation is unconspicuous because of alteration, the lateral ribs are present and persist until the middle part of the flanks. The suture line seems to be rather simple (Text-Fig. 13). Such features (DOMMERGUES et al., 1986, in press) are characteristic of the genus *Parasteroceras*.



Text-Fig. 13.
Parasteroceras sp. suture line.

As in FUCINI (1905, Pl. 1, Fig. 5), the body chamber is very extra-umbilicate.

By comparison with the two species nowadays known *P. pulchellum* FUCINI and *P. rakusi* DOMMERGUES, FAURE & PEYBERNES, the ventral area is thinner.

Local range: *Parasteroceras* sp. horizon, Raricostatum zone (Adnet quarry 28).

Family: Oxynoticeratidae HYATT 1875
Genus: *Oxynoticeras* HYATT 1875

Type species: *Ammonites oxynotus* QUENSTEDT 1845.

Oxynoticeras gr. *oxynotum* (QUENSTEDT 1845)

(Pl. 9, Fig. 2)

1845 *Ammonites oxynotus* QUENSTEDT, Pl. 5, Fig. 11.
1956 *Oxynoticeras oxynotum* (QUENSTEDT). – SÖLL, Pl. 17, Fig. 1–10; Pl. 18, Fig. 1.
1961 *Oxynoticeras oxynotum* (QUENSTEDT). – DEAN, DONOVAN & HOWARTH, Pl. 66, Fig. 5; Pl. 67, Fig. 3.
1984 *Oxynoticeras oxynotum* (QUENSTEDT). – CORNA, Pl. 11, Fig. 5.
1985 *Oxynoticeras oxynotum* (QUENSTEDT). – COMAS RENGIFO, Pl. 2, Fig. 6 with synonymy.
1990 *Oxynoticeras oxynotum* (QUENSTEDT). – HOLLINGWORTH, Pl. 1, Fig. 7–9.
1993 *Oxynoticeras oxynotum* (QUENSTEDT). – DOMMERGUES, Pl. 4, Fig. 5.

This suboxycone *Oxynoticeras* presents rather coarse spaced arched forward ribs with slightly prorsiradiate primaries on the sides, and intercalatories close to the venter. It bears a characteristic pinched keel. This morphological features well agree with the diagnosis of *O. oxynotum* (QUENSTEDT). *O. polyophyllum* (SIMPSON), a close species, bears a coarser ornamentation.

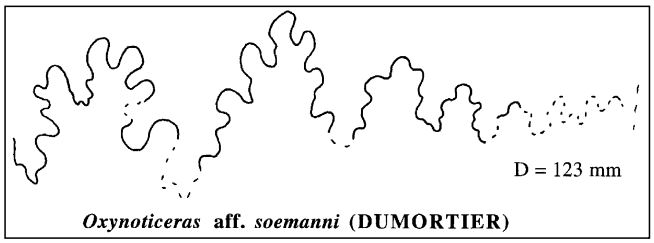
Local range: *oxynotum* level, Oxynotum zone (Museum of Adnet).

Oxynoticeras aff. *soemanni* (DUMORTIER 1867)

(Pl. 7, Figs. 3, 4)

1867 *Ammonites soemanni* DUMORTIER, Pl. 40, Fig. 2–4; Pl. 43, Fig. 1, 2.
1879 *Oxynoticeras soemanni* (DUMORTIER). – REYNES, Pl. 45, Fig. 44–46.
1901 *Oxynoticeras soemanni* (DUMORTIER). – FUCINI, Pl. 1, Fig. 1.
1914 *Oxynoticeras soemanni* (DUMORTIER). – PIA, Pl. 6, Fig. 25; Pl. 10, Fig. 4.
?non 1991 *Oxynoticeras soemanni* (DUMORTIER). – COPE, Pl. 4, Fig. 4.

Very oxycone and smooth specimens the morphology of which can suggest *Radstockiceras*. Nevertheless in the adult morphology the whorl section becomes more rounded and broader in the lower 1/3 of the sides, features which are characteristic of the genus *Oxynoticeras*. The suture line is quite simple (Text-Fig. 14).



Text-Fig. 14.
Oxynoticeras aff. *soemanni* (DUMORTIER) suture line.

Local range: *Parasteroceras* sp. horizon, Raricostatum zone (Adnet quarry 28).

Genus: *Gleviceras* BUCKMAN 1918

Type species: *Gleviceras glevense* BUCKMAN 1918.

Remark: Two main types of morphology can be recognized among the *Gleviceras* collected in the Adnet area. They specially differ by the periumbilical edge which is more or less angular and by the ventral part which is shouldered or compressed.

Gleviceras doris (REYNES) sensu PIA 1914

(Pl. 9, Fig. 1)

no 1879 *Ammonites doris* REYNES, Pl. 41, Fig. 13–15.
1914 *Oxynoticeras doris* (REYNES). – PIA, Pl. 1, Fig. 1; Pl. 6, Fig. 1; Pl. 8, Fig. 1.
? 1987 *Gleviceras* aff. *doris* (REYNES). – CECCA, DOMMERGUES, MOUTERDE & PALLINI, Pl. 2, Fig. 1.

Gleviceras is characterized by rather coarse ribs, by a large whorl section and by a shouldered ventral area. Moreover the periumbilical area is abruptly rounded and the umbilical wall is large (see PIA, Pl. 8, Fig. 1). *G. boucaultianum* (DUMORTIER) sensu PIA shows great affinities but the more compressed whorl section is not so clearly shouldered.

G. greenoughi (SOWERBY) in PARONA (1896, Pl. 1, Fig. 2) presents a more finely ribbing and its periumbilical area is not so abruptly rounded (less angular).

Local range: *Parasteroceras* sp. horizon, Raricostatum zone (Adnet quarry 28).

Gleviceras greenoughi (SOWERBY) sensu HAUER 1856

(Pl. 9, Fig. 3)

1856 *Ammonites greenoughi* SOWERBY. – HAUER, Pl. 12, Fig. 1–5.
aff. 1860 *Ammonites greenoughi* SOWERBY. – OOSTER, Pl. 16, Fig. 1, 2.
1914 *Oxynoticeras greenoughi* sensu (HAUER non SOWERBY). – PIA, Pl. 7, Fig. 30; Pl. 8, Fig. 5.
aff. 1958 *Oxynoticeras (Gleviceras)* aff. *doris* (REYNES non SOWERBY). – DONOVAN, Text-Fig. 1 b, c.

This *Gleviceras* shows a subelliptical rather compressed whorl section and rather coarse spaced and sinuous lateral ribs. The periumbilical area is smoothly rounded, oblique without angle, moreover the umbilicus is less deep than in *Gleviceras doris* (REYNES sensu PIA). In *G. subguibalianum* PIA also collected in the Adnet area, the rib density is finer and closer, ribs are less sinuous, the section is more compressed. Besides *G. victoris* (DUMORTIER) presents narrower whorl section and finer, closer ribbing.

A large specimen (D = 300 mm) shows a more rigid and closer ribbing and the ventral part perhaps is a little more shouldered until the adult stage. But the variability and ontogenetic development of these *Gleviceras* from the Adnet area is not well understood.

Local range: aff. *gigas* level, ? Oxynotum – Raricostatum zone (Adnet quarry 12).

Family: Echioceratidae BUCKMAN 1913
Genus: *Tmaegophioceras* SPATH 1925

Type species: *Arietites laevis* GEYER 1886.

Tmaegophioceras laeve (GEYER 1886)

(Pl. 8, Fig. 3)

1886 *Arietites laevis* STUR. – GEYER, Pl. 3, Fig. 10.
1984 *Tmaegophioceras laeve* (GEYER). – GECZY & SCHLATTER, p. 95, Abb. 3.

Very rare serpenticone ammonite with a subquadrate depressed whorl section, flat keeled venter bordered by two rather large sulci. In this taxon the ornamentation is unconspicuous and if it exists, reduced to spaced smooth undulations.

Local range: Probably upper part of Obtusum zone (see GECZY & SCHLATTER, 1984) [Adnet quarry 41].

Superfamily: Eoderocerataceae SPATH 1929
Family: Eoderoceratidae SPATH 1929
Genus: *Microderoceras* HYATT 1871

Type species: *Ammonites birchi* SOWERBY 1820.

Microderoceras aff. *gigas* (QUENSTEDT, 1883)

(Pl. 8, Fig. 2)

1882/85 *Ammonites birchii gigas* QUENSTEDT, Pl. 18, Fig. 13.
1928 *Microderoceras gigas* (QUENSTEDT) – BUCKMAN, Pl. 762.
1993 *Microderoceras* aff. *gigas* (QUENSTEDT). – MEISTER & BÖHM, Pl. 3 Fig. 3.

This large evolute ammonite (D = 300–350 mm) shows a spaced coarse and bituberculate ribbing. This ornamentation persists until the adult body chamber. *Microderoceras* aff. *gigas* (QUENSTEDT) co-occurs with *Gleviceras greenoughi* (SOWERBY sensu HAUER).

Local range: Coming from one isolated bed from the quarry (No 12), their exact biostratigraphical position cannot be precised. At the present time *Gleviceras* is not known before the Oxynotum zone; this suggests an age among Oxynotum and Raricostatum zones (aff. *gigas* level) [Adnet quarry 12].

Family: Coeloceratidae HAUG 1910
Genus: *Miltoceras* WIEDENMAYER 1980

Type species: *Aegoceras sellae* GEMMELLARO 1884.

Miltoceras (?) sp.

(Pl. 3, Fig. 10)

1993 *A. (Miltoceras)* juv. – MEISTER & BÖHM, Pl. 4, Fig. 12.

We bring near to the genus *Miltoceras* a fragment of an evolute ammonite characterized by a subrounded whorl section, high latero-ventral row of small tubercles, rather close lateral ribbing and ventral secondary ribs. It is very close to the specimen illustrated by MEISTER & BÖHM (1993, Pl. 4, Fig. 12).

Local range: *rejectum* horizon, Obtusum zone (Adnet quarry 38).

Family: Liparoceratidae HYATT 1867
Genus: *Paramicroderoceras* DOMMERGUES, FERRETTI & MEISTER 1994

Type species: *Microderoceras birchioides* ROSENBERG 1909.

Paramicroderoceras sp.

(Pl. 8, Fig. 4)

These specimens well correspond to the diagnosis of the genus *Paramicroderoceras* (DOMMERGUES et al., 1994). They are subplaticone-evolute ammonites bearing a complex ornamentation. Rather unconspicuous primary bituberculated ribs support clear secondary striae which are present during almost the entire ontogeny (DOMMERGUES et al., 1994) as well on the sides as on the ventral part.

The specific distinction is more complex specially because of the scarcity of the material.

The whorl expansion rate of the Adnet specimens seems to be moderate in the first whorls (until 70–80 mm of diameter) but slightly increases in the intermediate whorls (near 120 mm of diameter). Our specimens show affinities with *P. birchiades* (ROSENBERG) and with *P. nothum* (MENEGHINI in FUCINI). Nevertheless *P. birchiades* (ROSENBERG) has finer and closer secondary ribbing and in *P. nothum* (MENEGHINI in FUCINI) the primary ornamentation is more developped on the ventral part. The other morphologies regrouped in *P.* sp. A and *P.* sp. B by CECCA et al. (1987) and DOMMERGUES et al. (1994) differ by their higher whorl section, with more attenuated ornamentation in *P.* sp. A and well developed lateral primary ribbing for *P.* sp. B.

Local range: *Parasteroceras* sp. horizon, Raricostatum zone (Adnet quarry 28).

Genus: *Androgynoceras* HYATT 1867

Type species: *Ammonites hybrida* d'ORBIGNY 1844.

Androgynoceras gr. *geyeri* (SPATH 1938)

(Pl. 9, Fig. 4)

*1938 *Liparoceras geyeri* SPATH, Pl. 4, Figs. 4, 6; Pl. 6, Fig. 2; Pl. 10, Figs. 3. 4; Pl. 18, Fig. 11.
1990 "*Androgynoceras*" *geyeri* (SPATH). – DOMMERGUES, MEISTER & METTRAUX, Pl. 5, Fig. 12; with synonymy.
1991 *Androgynoceras* gr. *geyeri* (SPATH). – BLAU & MEISTER, Pl. 5, Fig. 3–5.

Small sized dimorphic ammonite characterized by a juvenile "capricorne" stage followed by a "*Liparoceras*" adult one. In our specimen, the short "capricorne" *Beaniceras* like stage suggests the *A. geyeri* (SPATH) group rather than *A. hybrida* (d'ORBIGNY) or *A. subhybrida* (SPATH) which are quite larger sized ammonites.

Local range: *geyeri* level, Ibex zone (Wetzsteingraben).

Family: Amaltheidae HYATT 1867
Genus: *Amaltheus* DE MONTFORT 1808

Type species: *Amaltheus margaritatus* DE MONTFORT 1808.

Amaltheus stokesi (SOWERBY 1818)

(Pl. 10, Fig. 1)

*1818 *Ammonites Stokesi* MONTFORT, Pl. 190.
1958 *Amaltheus stokesi* (MONTFORT). – HOWARTH, Pl. 1, Figs. 5, 7, 12–14; Pl. 2, Figs. 1, 3, 10; Text-Figs. 4, 5; with synonymy.
1986 *Amaltheus stokesi* (MONTFORT). – MEISTER, Pl. 19, Fig. 2; Pl. 20, Figs. 1, 8; with synonymy.
1991 *Amaltheus stokesi* (SOWERBY). – BLAU & MEISTER, Pl. 5, Fig. 9 with synonymy.
1993 *Amaltheus (Amaltheus) stokesi* (SOWERBY). – Pl. 1, Fig. 7.

Classical *Amaltheus* species for the lower part of the Domerian in the Euroboreal realm, *A. stokesi* (SOWERBY) is characterized by a slightly sigmoid lateral ribbing and by a crenulate keel which remains connected with ribs.

Local range: *isseli* level, Margaritatus zone (Wetzsteingraben).

Amaltheus margaritatus DE MONTFORT 1808

(Pl. 9, Fig. 5)

*1808 *Amaltheus margaritatus* DE MONTFORT, p. 91, Fig. 90.
1958 *Amaltheus margaritatus* DE MONTFORT. – HOWARTH, Pl. 3, Figs. 4–6; Text-Figs. 8, 9; with synonymy.
1986 *Amaltheus margaritatus* DE MONTFORT. – MEISTER, Pl. 20, Fig. 9; Pl. 22, Fig. 1; Pl. 23, Fig. 6; with synonymy.
1988 *Amaltheus margaritatus* DE MONTFORT. – MEISTER, Pl. 1, Figs. 2–4; Pl. 2, Figs. 1–3, 5; Pl. 3, Figs. 3–5, 10; Pl. 4, Figs. 1, 3, 4.
1991 *Amaltheus margaritatus* DE MONTFORT. – BLAU & MEISTER, Pl. 5, Fig. 10.

These and poorly preserved specimens come from the *A.* gr. *algovianum* (OPPEL) levels. They are typical *Amaltheus* characterized by clearly disconnected ribs and a crenulated keel. Moreover the crenulation of the keel is not as coarse as in *A. stokesi* (SOWERBY).

Local range: *algovianum* level, Margaritatus zone (Wetzsteingraben).

Superfamily: Hildocerataceae HYATT 1867
Family: Hildoceratidae HYATT 1867
Subfamily: Harpoceratinae NEUMAYR 1875
Genus: *Protogrammoceras* SPATH 1913

Type species: *Grammoceras bassanii* FUCINI 1900.

Protogrammoceras gr. *isseli* (FUCINI 1900)

(Pl. 9, Fig. 6; Pl. 10, Figs. 4, 8)

1900 *Grammoceras isseli* FUCINI, Pl. 9, Fig. 6–8.
1983 *Fuciniceras isseli* (FUCINI). – BRAGA, Pl. 2, Fig. 10; Pl. 3, Fig. 1–5.
1983 *Protogrammoceras isseli* (FUCINI). – DOMMERGUES, FERRETTI, GECZY & MOUTERDE, Pl. 4, Fig. 1–12.
1991 *Protogrammoceras* gr. *isseli* (FUCINI). – BLAU & MEISTER, Pl. 5, Figs. 15–22.
1993 *Protogrammoceras* cf. *isseli* (FUCINI). – MEISTER & BÖHM, Pl. 8, Figs. 11, 14.

Protogrammoceras with falcate, fine and close ribs. Toward the end of the growth the rib density increases and the ventral area becomes more rounded.

Local range: *isseli* level, Margaritatus zone (Wetzsteingraben).

Subgenus: *Paltarpites* BUCKMAN 1922

Type species: *Paltarpites paltus* BUCKMAN 1922.

P. (Paltarpites) sp.

We attribute to this subgenus two fragments of body chamber of quite large involute *Protogrammoceras* characterized by a high compressed whorl section bearing an acute fine keel and showing falcate, very fine and close ribs.

P. (P.) meneghini (BONARELLI) is a closer ribbed taxon and conversely *P. (P.) ilurcense* BRAGA displays coarser and more spaced ribs.

Local range: *algovianum* level, Margaritatus zone (Wetzsteingraben).

Subfamily: Arieticeratinae HOWARTH 1955
Genus: *Arieticeras* SEGUENZA 1885

Type species: *Ammonites algovianus* OPPEL 1862.

Arieticeras gr. *algovianum* (OPPEL 1862)

(Pl. 10, Figs. 2, 3, 5–7)

1862 *Ammonites Algovianum* OPPEL, p. 137.
1988 *Arieticeras* cf. *algovianum* – SMITH, TIPPER, TAYLOR & GUEX, Pl. 4, Fig. 10, 11.
1989 *Arieticeras* gr. *algovianum* (OPPEL). – MEISTER, Pl. 7, Fig. 10–12 with synonymy.
1991 *Arieticeras* gr. *algovianum* (OPPEL). – BLAU & MEISTER, Pl. 6, Fig. 23; Pl. 7, Fig. 1–18.
1993 *Arieticeras* gr. *algovianum* (OPPEL). – MEISTER & BÖHM, Pl. 9, Fig. 5, 7–10.
1993 *Arieticeras* ex. gr. *algovianum* (OPPEL). – JAKSCH, Pl. 2, Fig. 1.

These forms belong to a faunal set already described from the Lienz Dolomites (BLAU & MEISTER, 1991), from the Salzburg area and Rötelstein (MEISTER & BÖHM, 1993).

Local range: *algovianum* level, Margaritatus zone (Wetzsteingraben).

Genus: *Leptaleoceras* BUCKMAN 1918

Type species: *Leptaleoceras leptum* BUCKMAN 1918.

Leptaleoceras aff. *accuratum* (FUCINI 1931)

(Pl. 10, Figs. 9–11)

1931 *Arieticeras* (?) *accuratum* FUCINI , Pl. 8, Fig. 7, 8.
non 1952 *Arieticeras accuratum* FUCINI. – VENZO, Pl. A, Fig. 8, 9.
1968 *Arieticeras accuratum* FUCINI. – CANTALUPPI & BRAMBILLA, Pl. 27, Fig. 1.
1977 *Ugdulunia accurata* (FUCINI). – FANTINI SESTINI, Pl. 37, Fig. 7; Pl. 38, Fig. 7, 8; Pl. 39, Fig. 1–9.
1980 *Arieticeras accuratum* FUCINI. – WIEDENMAYER, Pl. 17, Fig. 15–18.
1982 *Leptaleoceras accuratum* (FUCINI). – BRAGA, COMAS RENGIFO, GOY & RIVAS, Pl. 3, Fig. 1.
1983 *Leptaleoceras accuratum* (FUCINI). – BRAGA, Pl. 12, Fig. 3–10.
? 1983 *Leptaleoceras accuratum* (FUCINI) *preaccuratum* BRAGA, Pl. 11, Fig. 27–30; Pl. 12, Fig. 1, 2.
1985 *Arieticeras accuratum* FUCINI. – COMAS RENGIFO, Pl. 16, Fig. 1, 2.
? 1988 *Leptaleoceras* aff. *accuratum* (FUCINI). – SMITH, TIPPER, TAYLOR & GUEX, Pl. 4, Fig. 9.

The Arieticeratinae co-occur with *Arieticeras* gr. *algovianum* (OPPEL). They are evolute compressed forms with a narrow ventral area bearing a keel but without sulci. The rather evanescent ornamentation is rather rigid. The ribbing is less sinuous and the umbilicus more opened than in "*A.*" *ugdulenai* (GEMMELLARO).

Local range: *algovianum* level, Margaritatus zone (Wetzsteingraben).

5. Biostratigraphical Framework

For the use of the terms "horizon" or "level", we refer to MEISTER et al. (1994, p. 141).

LATE HETTANGIAN to EARLY SINEMURIAN

Angulata Zone to Bucklandi Zone

Complanata subzone to Conybeari subzone

marmorea horizon

A ferromanganese level forms the base of the red Adnet Limestones in the quarries of Adnet. A biostratigraphical condensation of this ammonite rich level is possible, but cannot be demonstrated by the analysis of our material. The ammonite assemblage includes *Schlotheimia marmorea*, *Phylloceras* sp., Juraphyllitidae sp., *Pseudaetomoceras abnormilobatus*, *Paracaloceras* aff. *grunowi*, *Paracaloceras* sp., Arietitidae ssp. (Text-Fig. 15). This association and the stratigraphical context cannot clearly indicate a precise age which still imposes some discussion (GUEX & TAYLOR, 1976; BLOOS, 1983, 1988; TAYLOR, 1986, 1990). If *Schlotheimia marmorea* seems to indicate a Late Hettangian age (BLOOS, 1988, p. 74) the other associated taxa are Arietids and suggest the Early Sinemurian (TAYLOR, 1986, 1990).

EARLY SINEMURIAN

Our data from the Early Sinemurian are rare and the major part of the material was collected ex situ. If it is in situ, the places of collect are too much isolated to propose any local correlations. Nevertheless all specimens come from the lower part of the Adnet Limestones sequence not far from the bottom of the quarries. By comparison with the sequences of well studied areas like the southern Jura (CORNA, 1985, 1987), we can suspect that our material comes from several levels:

adnethicus level

A level, slightly above the suspected condensed *marmorea* horizon, contains *Adnethiceras adnethicus*, some Arietitidae sp. and *Arnioceras* (?) sp. Its age is to place in an interval including the Bucklandi zone and the Semicostatum one.

cf. *lyra* level

A *Coroniceras* cf. *lyra*, ex situ, also suggests the lower part of Semicostatum zone (Charlesi subzone)

Caenisites sp. level

The presence of *Caenisites* sp. and *Arnioceras* sp., in an ex situ assemblage, attests the presence of the Turneri zone.

gr. *paucicostum* horizon

The *Arnioceras* gr. *paucicostum* horizon is characterized by the index species, *Phylloceras cylindricum*, *Juraphyllites* sp., *Angulaticeras* (*Boucaulticeras*) sp. This faunal event is well represented throughout the Salzburg area and was previously described in the Schmiedwirt locality by MEISTER & BÖHM (1993) as *mendax* horizon. It can also be correlated with the *Arnioceras* sp. level from Breitenberg (MEISTER & BÖHM, 1993). Because of the long range of *Arnioceras* species, it is difficult to precise an age but one can suggest a period between the Semicostatum zone and the lower part of Obtusum zone. The problem is similar for the Central Apennine succession (DOMMERGUES et al., 1994). In that case, *Arnioceras* gr. *paucicostum* is associated with "*Ectocentrites*" *altiformis* BONARELLI, *Bouhamidoceras* sp. and "*Microderoceras*" cf. *olenoptychum* (FUCINI) (Text-Fig. 16).

LATE SINEMURIAN

Obtusum Zone

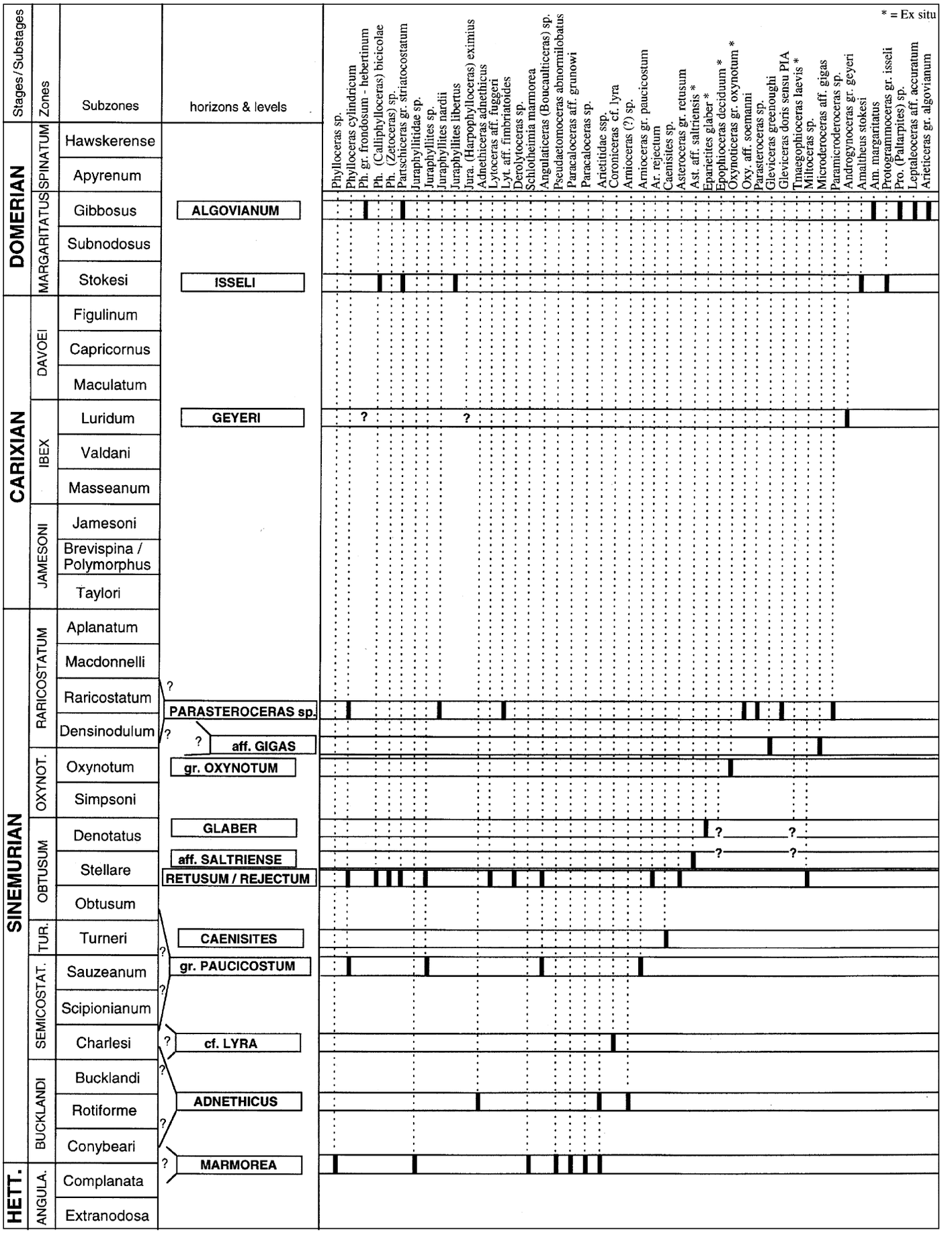
Stellare subzone

gr. *retusum* horizon

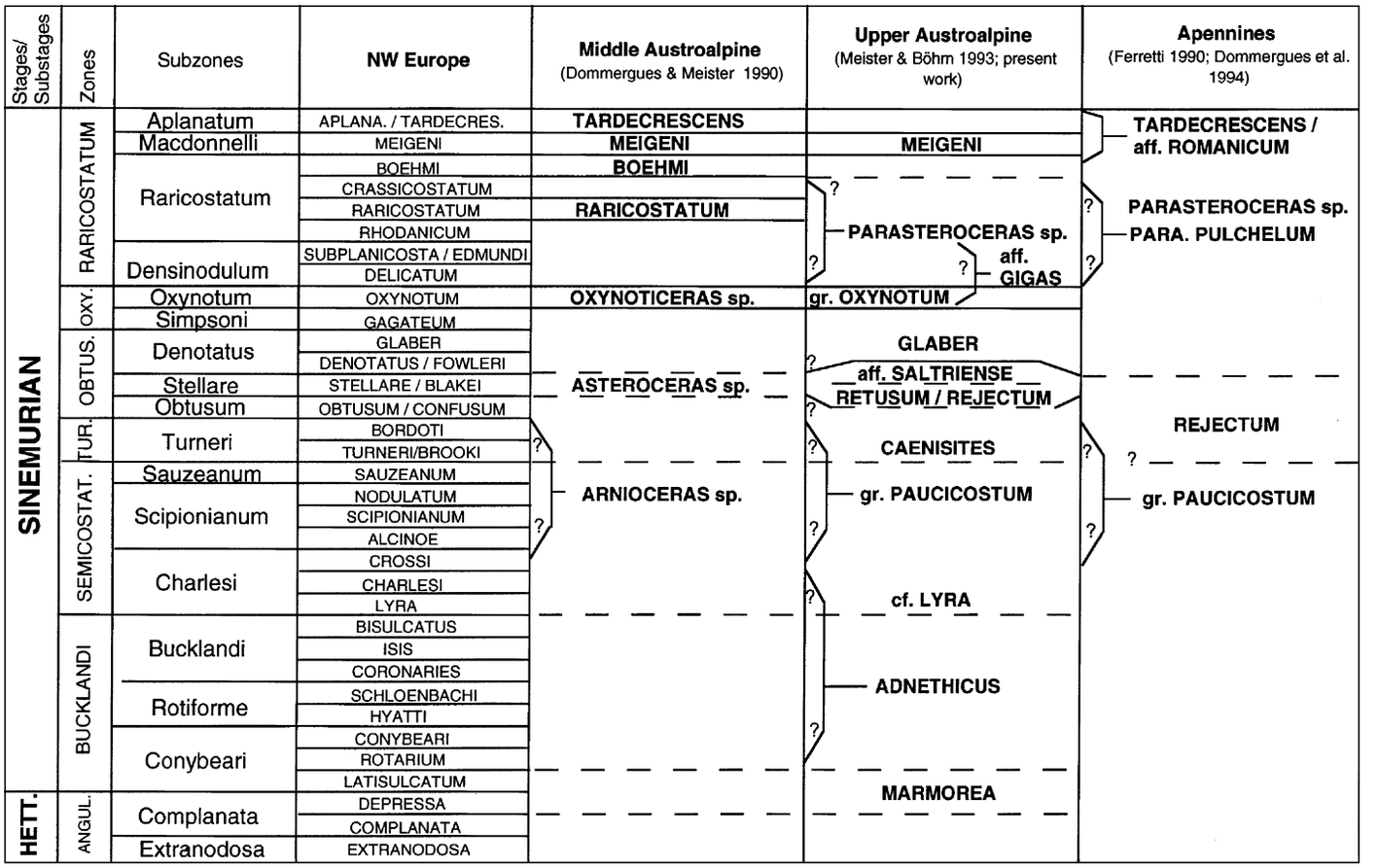
This horizon which is characterized by the association of *Asteroceras retusum* sensu SACCHI-VIALLI & CANTALUPPI, *Arnioceras rejectum*, *Angulaticeras* (*Boucaulticeras*) sp., *Phylloceras cylindricum*, *Ph. (Calliphylloceras) bicicolae*, *Ph. (Zetoceras)* sp., *Partschiceras* gr. *striatocostatum* (from Glasenbach). *Miltoceras* (?) sp., *Derolytoceras* sp., *Lytoceras* aff. *fuggeri* and *Juraphyllites* sp. *Asteroceras retusum*, clearly indicates the Stellare subzone, probably the lower or middle part of this biochronologic unit.

aff. *saltriensis* level
(called *stellare* level in MEISTER & BÖHM, 1993).

We have collected ex situ *Asteroceras* aff. *saltriensis*, a species which seems to indicate the upper part of the Stellare subzone. Indeed its morphology is already close to that of the genus *Aegasteroceras* from the top of the Stellare subzone.



Text-Fig. 15.
Biostratigraphical framework of the studied areas.



Text-Fig. 16.
Biostratigraphical comparisons and correlations between NW Europe, Middle Austroalpine, Upper Austroalpine and Apennines.

The two latter assemblages can be roughly correlated with the *Asteroceras* sp. horizon from the Middle Austroalpine (DOMMERGUES & MEISTER, 1990) and with the *rejectum* horizon from the Central Apennine (DOMMERGUES et al., 1994). Nevertheless in Italy, the interval of doubt for its zonal or subzonal attribution is still wider.

Coming probably from the Obtusum zone *Epophioceras deciduum* and *Tmaegophioceras laeve* also indicate the Stellare subzone or perhaps the base of the Denotatus one (GECZY & SCHLATTER, 1984).

Denotatus subzone

glaber level

An ex situ specimen of *E. glaber* suggests the upper part of the Denotatus subzone.

Oxynotum Zone

Oxynotum subzone

gr. *oxynotum* level

Only one *O.* gr. *oxynotum*, also ex situ, allows us to attest the presence of the Oxynotum subzone on the Adnet area. Tentative correlations can be proposed with the Middle Austroalpine where an episode with *Oxynoticeras* is described.

aff. *gigas* level

The assemblage including *Microderoceras* aff. *gigas* and *Gleviceras greenoughi* sensu HAUER is difficult to correlate with the standard NW european zonation. Indeed the usually admitted vertical distribution of the genus *Gleviceras* begins from the Oxynotum zone and includes the Raricostatum zone meanwhile the distribution of *Microderoceras* aff. *gigas* is restricted to the Turneri zone.

Raricostatum Zone

Densinodulum and Raricostatum subzones

Parasteroceras sp. horizon

By comparison with the Central Apennines (DOMMERGUES et al., 1994) we attribute with doubt the *Parasteroceras* sp. horizon to the lower-middle part of the Raricostatum zone. The fauna is characterized by *Parasteroceras* sp., *Paramicroderoceras* sp., *Oxynoticeras* aff. *soemanni*, *Gleviceras doris* sensu PIA, *Phylloceras cylindricum*, *Juraphyllites nardii*.

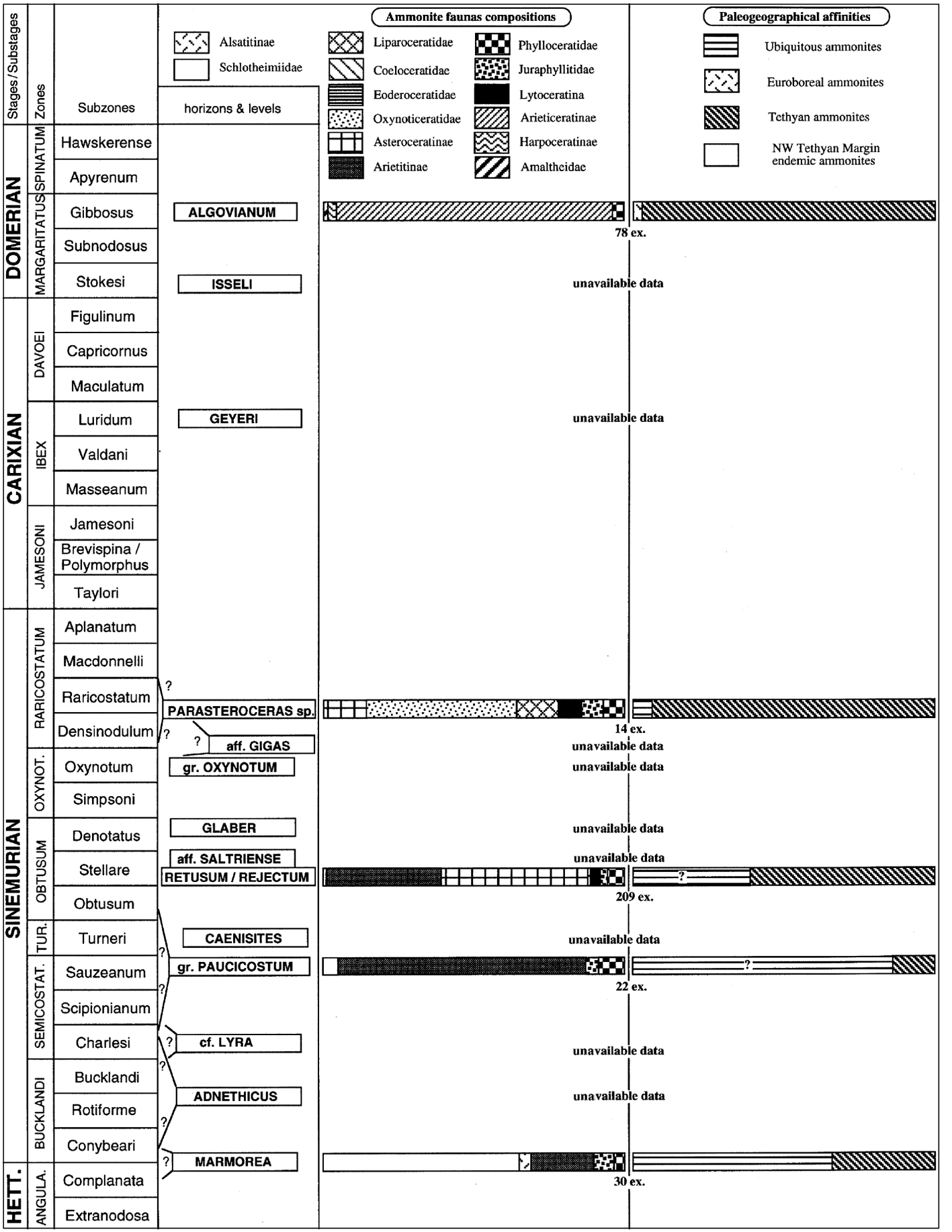
A *Lytoceras* aff. *fimbriatoides* collected about 40 cm below this horizon, can also be attributed to the Raricostatum zone.

In the Central Apennine, two *Parasteroceras* assemblages can be proposed; but the faunal associations which are different from the alpine ones, do not allow precise correlations.

PLIENSBACHIAN

CARIXIAN SUBSTAGE

All the Pliensbachian taxa described here are coming from Wetzsteingraben. This Liassic outcrop is a distorted olistolith and no precise biostratigraphy is possible. Meanwhile by comparison with established successions in the Lienz (BLAU & MEISTER, 1991), Salzburg and Rötelstein areas (MEISTER & BÖHM, 1993) we can propose to



Text-Fig. 17.
Faunal composition and paleogeographical affinities.

gather the species in several hypothetical levels. Each assemblage proposed here is characterized by specimens which have been collected together in a well determined tectonic block.

Ibex Zone

Luridum subzone

gr. *geyeri* level

The Carixian is only reliably attested by the presence of *Androgynoceras* gr. *geyeri*, a species indicating the Middle Carixian.

J. (Harpophylloceras) eximius and some *Phylloceras* sp. are also probably coming from this Middle Carixian assemblage.

DOMERIAN SUBSTAGE

Margaritatus Zone

Stokesi subzone

gr. *isseli* level

The presence of *Amaltheus stokesi*, *P. (Calliphylloceras) bicicolae* and *Partschiceras* gr. *striatocostatum*, *Juraphyllites libertus* and *Protogrammoceras* gr. *isseli* in the same assemblage characterizes the Stokesi subzone.

Gibbosus subzone

algovianum level

This biochronological unit is represented by the association of *Arieticeras algovianum*, *Leptaleoceras* aff. *accuratum*, *P. (Paltarpites)* sp., *Amaltheus margaritatus*, *Partschiceras* gr. *striatocostatum* and *Phylloceras* gr. *frondosum – hebertinum*.

*

The faunal ratio (Text-Fig. 17) must be taken with caution because of very discontinuous informations for the considered period and because of the very irregular number of specimens collected in each assemblage. Nevertheless the faunal compositions mainly show the weak "representativity" of the Phylloceratidae, Juraphyllitidae and Lytoceratidae in these "Ammonitico Rosso" facies. Moreover in each assemblage the diversity is rather high: 4 to 6 taxa.

For the paleogeographical affinities, the fauna is clearly dominated by the Tethyan ammonites with an episode, from the Late Hettangian to the Late Sinemurian, of decreasing appearance and nearly disappearance of the ubiquitous ammonites. We have here considered *Schlotheimia marmorea* (OPPEL), *Lytoceras* ssp. and *Arnioceras* ssp. as potential ubiquitous forms.

In the Pliensbachian, the faunal ratio in the *algovianum* horizon is almost the same in Wetzsteingraben, or in Rötelstein (MEISTER & BÖHM, 1993) and in the Lienz area (BLAU & MEISTER, 1991). It shows a relatively homogeneity from the South to the North of the Upper Austroalpine unit.

6. Conclusion

This paper is the first attempt to present a precise biostratigraphy for the Late Hettangian–Sinemurian of the Adnet quarries and to provide new elements for the correlations with the other parts of the western Tethys. But the studies for the Tethyan Sinemurian still remain too discontinuous. Moreover each outcrop (quarry) is charaterized by an original assemblage which does not allow detailed comparisons and correlations as well at a local as at a larger scale. Indeed the events recorded during the Sinemurian in this part of the Tethys seem to be rather heterogeneous and stochastic, perhaps reflecting a complex structuration of the Liassic platforms. Only further detailed studies of new regions will provide precisions.

Acknowledgements

Dr. CHRISTIAN MEISTER thanks very much the Fonds National Suisse de la Recherche Scientifique for its support (No 20-39394.93).

Plate 1

Fig. 1: ***Phylloceras* sp.**
Adnet, quarry 31, bed 10.
Angulata to ? Bucklandi zones.

Fig. 2: **Juraphyllitidae sp.**
Adnet, quarry 31, bed 10.
Angulata to ? Bucklandi zones.

Fig. 3: ***Phylloceras cylindricum* (SOWERBY).**
Adnet, quarry 38, bed 100.
Obtusum zone.

Fig. 4: ***P. (Zetoceras)* sp.**
Adnet, quarry 38, ex situ.
? Obtusum zone.

Fig. 5: ***Juraphyllites libertus* (GEMMELLARO).**
Wetzsteingraben, associated with ***Protogrammoceras*** gr. ***isseli*** (FUCINI).
Margaritatus zone.

Fig. 6: ***Juraphyllites nardii* (MENEGHINI).**
Adnet, quarry 28, bed 100.
Raricostatum zone.

Figs. 7, 8: ***Juraphyllites* sp.**
Fig. 7: Adnet, quarry 28, ex situ between beds 4–16a.
? Bucklandi – Semicostatum zones.
Fig. 8: Adnet, quarry 38, bed 100.
Obtusum zone.

Figs. 9,12: ***Partschiceras* gr. *striatocostatum* (MENEGHINI).**
Fig. 9: Wetzsteingraben, associated with *Arieticeras* gr. *algovianum* (OPPEL).
Margaritatus zone.
Fig. 12: Glasenbach, bed 3.
Semicostatum ? – Obtusum zones.

Fig. 10: ***J. (Harpophylloceras) eximius* (HAUER).**
Wetzsteingraben, ex situ.
? Ibex zone.

Fig. 11: ***P. (Calliphylloceras) bicicolae* (MENEGHINI).**
Wetzsteingraben, associated with *Protogrammoceras* gr. *isseli* (FUCINI).
Margaritatus zone.

All the ammonites are in natural size and come from the Museum of Adnet and the Natural History Museum of Geneva.

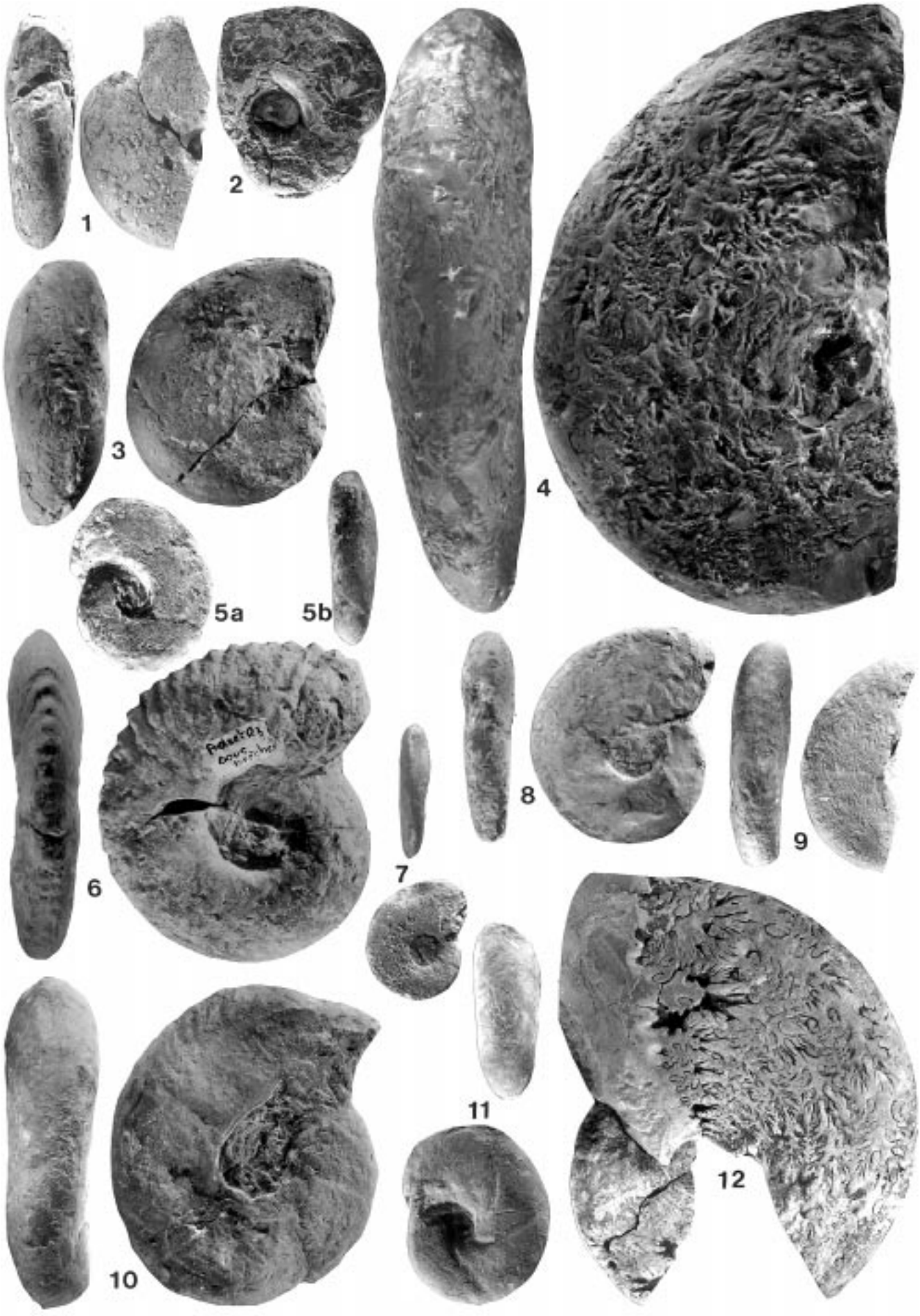

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Plate 2

Figs. 1,6: ***Adnethiceras adnethicus*** **(HAUER).**
Adnet, quarry 28, 1: bed 5 and 6: bed 12.
? Bucklandi – ? Semicostatum zones.

Figs. 2,3: ***Derolytoceras*** **sp.**
Adnet, quarry 38, bed 100.
Obtusum zone.

Figs. 4,7–9: ***Schlotheimia marmorea*** **(OPPEL).**
Adnet, quarry 31, bed 10.
Angulata to ? Bucklandi zones.

Fig. 5: ***Angulaticeras (Boucaulticeras)*** sp.
Adnet, quarry 41, bed 10.
Semicostatum – ? Obtusum zones.

All the ammonites are in natural size.

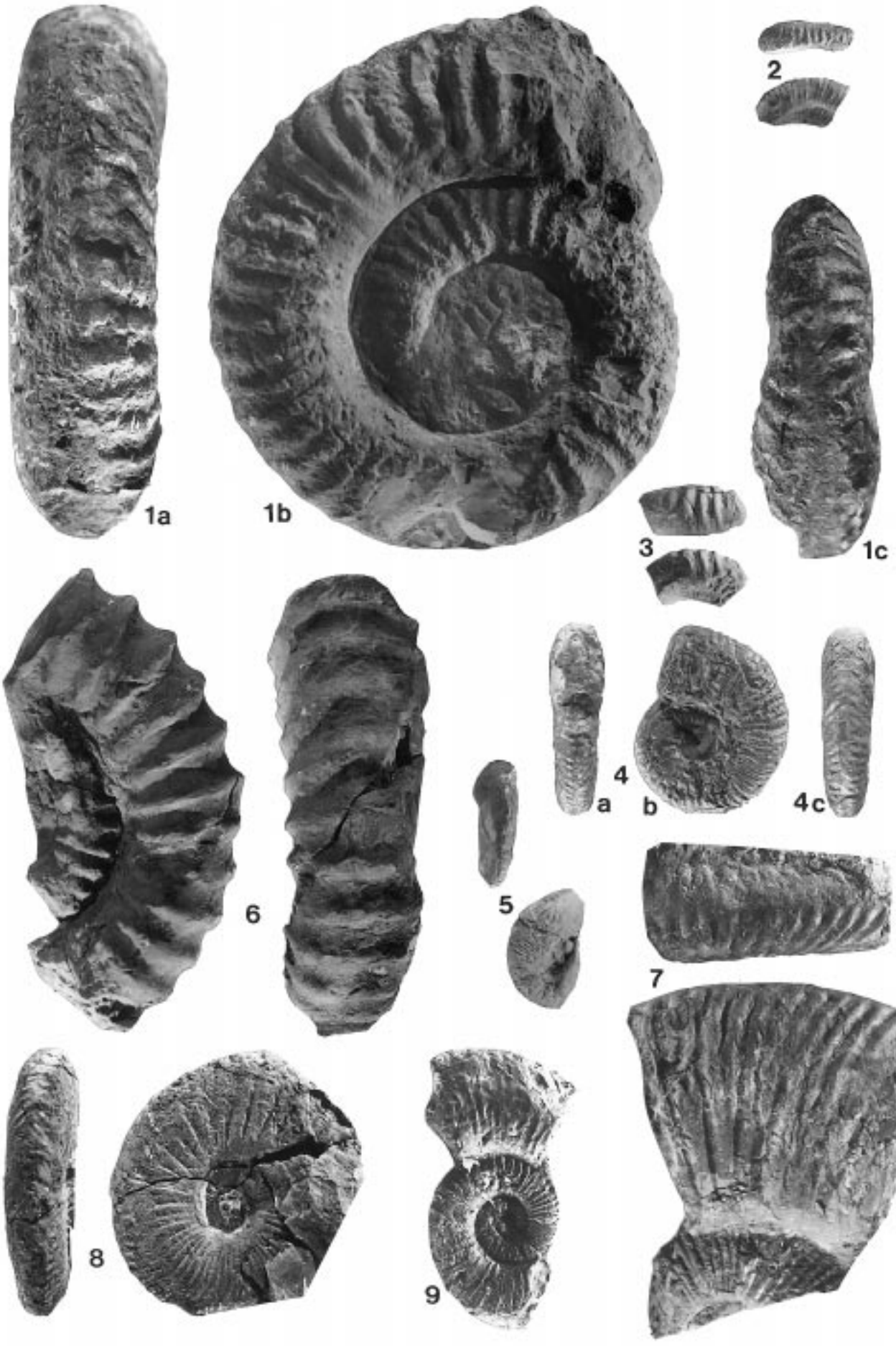
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Plate 3

Figs. 1,2: ***Schlotheimia marmorea* (OPPEL).**
Adnet, quarry 31, bed 10.
Angulata to ? Bucklandi zones.

Figs. 3, 8: ***Pseudaetomoceras abnormilobatus* (WÄHNER).**
Adnet, quarry 31, bed 10.
Angulata to ? Bucklandi zones.

Fig. 4: ***Paracaloceras* sp.**
Adnet, quarry 31, bed 10.
Angulata to ? Bucklandi zones.

Fig. 5: ***Paracaloceras* aff. *grunowi* (HAUER).**
Adnet, quarry 31, bed 10.
Angulata to ? Bucklandi zones.

Figs. 6,7,9: **Arietitidae sp.**
Fig. 6: Adnet, quarry 31, bed 10.
Angulata to ? Bucklandi zones.
Fig. 7: Adnet, quarry 28, bed 12.
:Bucklandi – ? Semicostatum zones.
Fig. 9: Adnet, quarry 28, bed 16a.
Bucklandi – ? Semicostatum zones.

Fig. 10: ***Miltoceras* (?) sp.**
Adnet, quarry 38, bed 100.
Obtusum zone.

Fig. 11: ***Arnioceras* gr. *paucicostum* sensu FERRETTI non FUCINI.**
Adnet, quarry 41, bed 10.
Semicostatum – ? Obtusum zones.

Fig. 13: ***Coroniceras* cf. *lyra* HYATT.**
Adnet, quarry 28, ex situ.
Early Sinemurian.

Figs. 12,14–16: ***Arnioceras rejectum* FUCINI.**
Fig. 12: Adnet, ex situ.
Semicostatum – ? Obtusum zones.
Figs. 14–16: Adnet, quarry 38, bed 100.
Obtusum zone.

All the ammonites are in natural size.

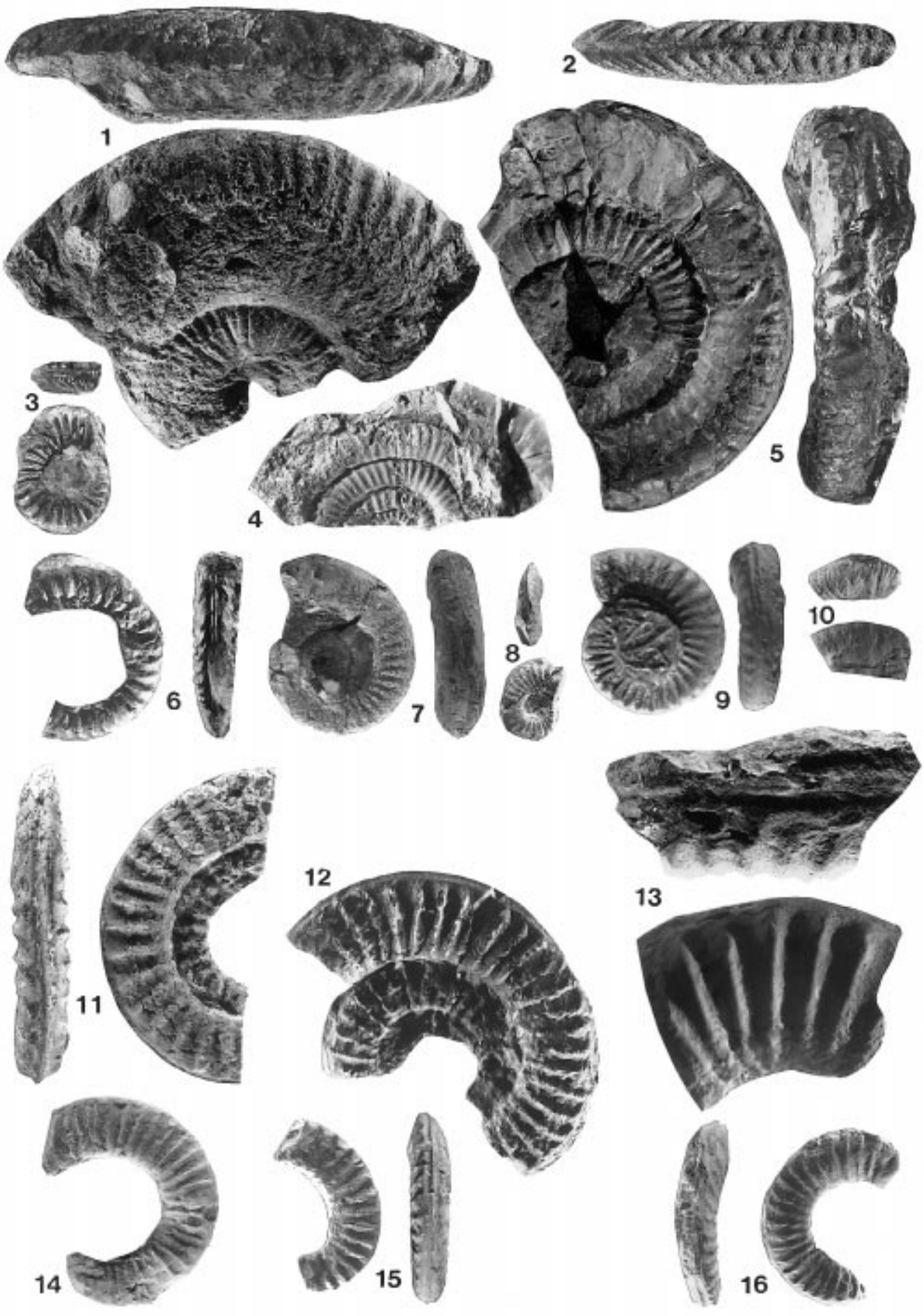
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Plate 4

Figs. 1,5: ***Arnioceras* gr. *paucicostum* sensu FERRETTI non FUCINI.**
Fig. 1: Glasenbach, bed 17.
Semicostatum – ? Obtusum zones.
Fig. 5: Adnet, quarry 41, bed 10.
Semicostatum – ? Obtusum zones.

Figs. 2–4: ***Arnioceras rejectum* FUCINI.**
Fig. 2: Adnet, quarry 38, bed 100.
Obtusum zone.
Figs. 3,4: Adnet, ex situ.
Semicostatum – ? Obtusum zones.

Figs. 6–10: ***Asteroceras* gr. *retusum* (REYNES) sensu SACCHI-VIALLI & CANTALUPPI.**
Adnet, quarry 38, bed 100.
Obtusum zone.

All the ammonites are in natural size.

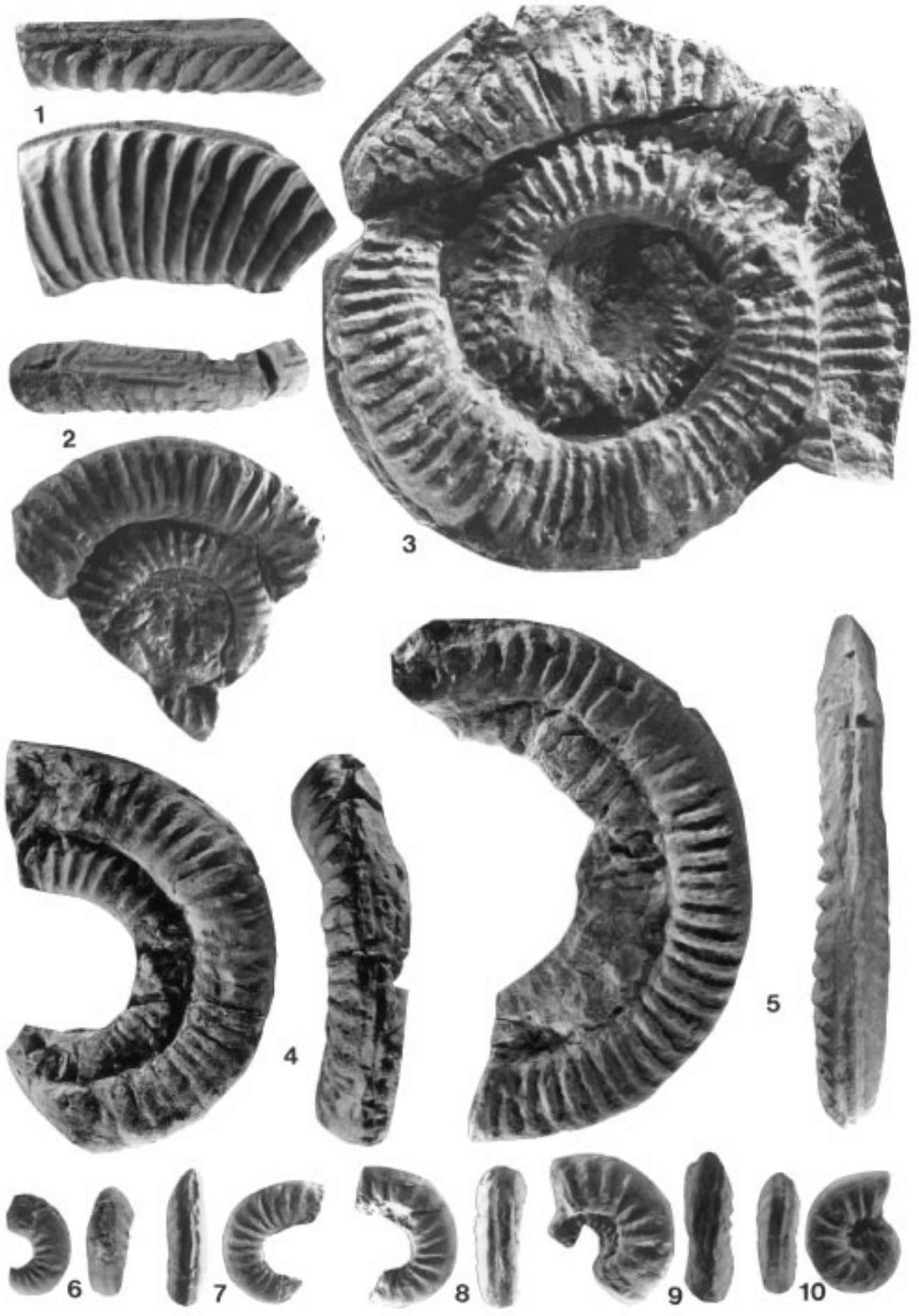
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Plate 5

Figs. 1–10: ***Asteroceras* gr. *retusum* (REYNES) sensu SACCHI-VIALLI & CANTALUPPI.**
Adnet, quarry 38, bed 100.
Obtusum zone.

Fig. 11: ***Asteroceras* aff. *saltriensis* (PARONA).**
Adnet, quarry 28, ex situ.
Obtusum zone.

All the ammonites are in natural size.


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Plate 6

Figs. 1,3: ***Epophioceras deciduum*** **(HYATT).**
Fig. 1: Museum of Adnet, ex situ.
Obtusum zone.
Fig. 3: Adnet, quarry 28, ex situ.
Obtusum zone.

Fig. 2: ***Parasteroceras*** **sp.**
Adnet, quarry 28, bed 100.
Raricostatum zone.

All the ammonites are in natural size.

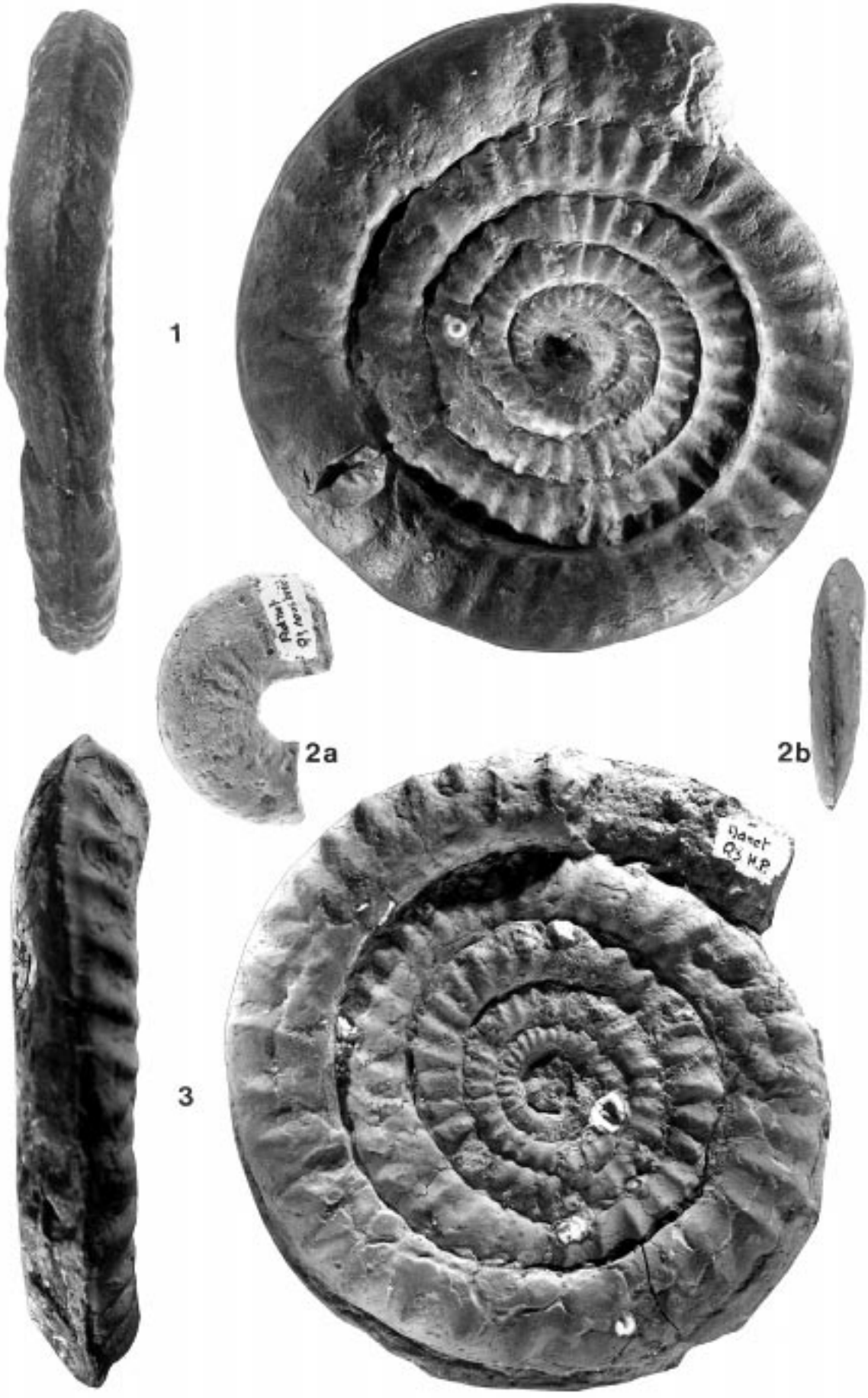
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Plate 7

Fig. 1: ***Eparietites glaber* GUERIN-FRANIATTE.**
Museum of Adnet, ex situ.
Obtusum zone.

Fig. 2: ***Parasteroceras* sp.**
Adnet, quarry 28, ex situ.
? Raricostatum zone.

Figs. 3,4: ***Oxynoticeras* aff. *soemanni* (DUMORTIER).**
Adnet, quarry 28, 3: bed 100 and 4: ex situ.
Raricostatum zone.

All the ammonites are in natural size.

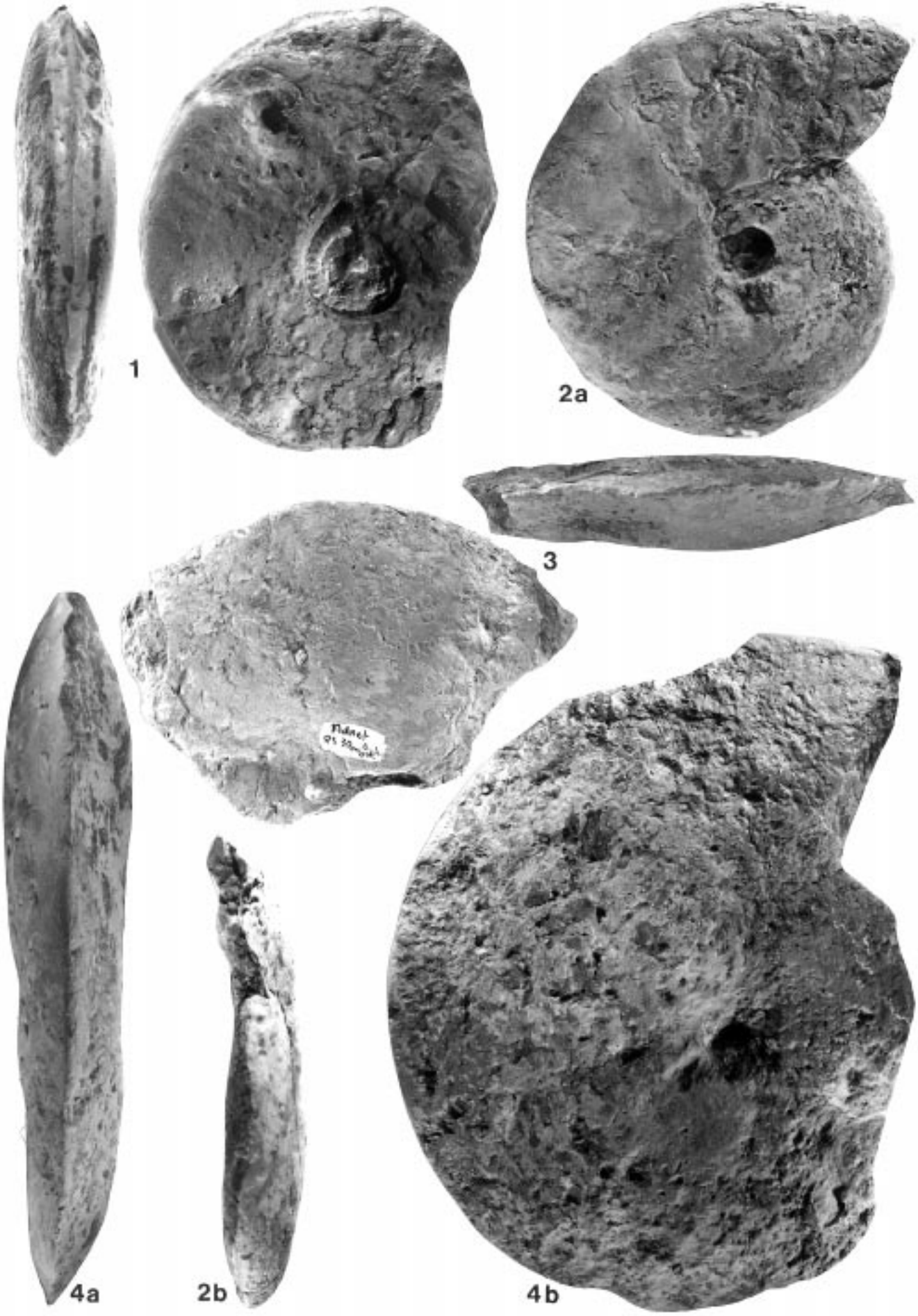
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Plate 8

Fig. 1: ***Parasteroceras* sp.**
Adnet, quarry 28, bed 100.
Raricostatum zone.

Fig. 2: ***Microderoceras* aff. *gigas* (QUENSTEDT).**
Adnet, quarry 12, bed 12.
Oxynotum – ? Raricostatum zones.

Fig. 3: ***Tmaegophioceras laeve* (GEYER).**
Adnet, ex situ.
? Obtusum zone.

Fig. 4: ***Paramicroderoceras* sp.**
Adnet, quarry 28, bed 100.
Raricostatum zone.

All the ammonites are in natural size.


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Plate 9

Fig. 1: ***Gleviceras doris* (REYNES) sensu PIA.**
Adnet, quarry 28, bed 100.
Raricostatum zone.

Fig. 2: ***Oxynoticeras* gr. *oxynotum* (QUENSTEDT).**
Museum of Adnet, ex situ.
Oxynotum zone.

Fig. 3: ***Gleviceras greenoughi* (SOWERBY) sensu HAUER.**
Adnet, quarry 12, bed 12.
Oxynotum – ? Raricostatum zones.

Fig. 4: ***Androgynoceras* gr. *geyeri* (SPATH).**
Wetzsteingraben.
Ibex zone.

Fig. 5: ***Amaltheus margaritatus* DE MONTFORT.**
Wetzsteingraben, associated with *Arieticeras* gr. *algovianum* (OPPEL).
Margaritatus zone.

Fig. 6: ***Protogrammoceras* gr. *isseli* (FUCINI).**
Wetzsteingraben.
Margaritatus zone.

All the ammonites are in natural size.


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Plate 10

Fig. 1: ***Amaltheus stokesi* (SOWERBY).**
Wetzsteingraben.
Margaritatus zone.

Figs. 2,3,5–7: ***Arieticeras* gr. *algovianum* (OPPEL).**
Wetzsteingraben.
Margaritatus zone.

Figs. 4,8: ***Protogrammoceras* gr. *isseli* (FUCINI).**
Wetzsteingraben.
Margaritatus zone.

Figs. 9–11: ***Leptaleoceras* aff. *accuratum* (FUCINI).**
Wetzsteingraben.
Margaritatus zone.

All the ammonites are in natural size.


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